

KEEN & WHITE

TEXT BOOK

OF SURGERY

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January 16th 1896

AN AMERICAN
TEXT-BOOK OF SURGERY,

FOR
PRACTITIONERS AND STUDENTS.

BY
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PREFACE TO THE SECOND EDITION.

THE success of the AMERICAN TEXT-BOOK OF SURGERY, as evinced by its extraordinary sale and its adoption as a text-book in over sixty medical schools in this country, as well as by a large sale abroad, has been most gratifying both to the editors and to their colleagues. The three years that have elapsed since the first edition was published have been years fruitful in surgical progress, and, accordingly, a number of topics have been added to the text, as well as others expanded which seemed to have had inadequate treatment in the first edition. An endeavor has been made to take advantage of the kindly criticism in the medical press to make good many deficiencies and to correct some errors. It is impossible to enumerate all of the many changes in the text, but among others may be mentioned the effect of modern small-arms in military surgery; a new section on Acromegaly; the Hartley-Krause method of removing the Gasserian ganglion; the osteoplastic method of resection of the skull, with a number of additions to operations and methods in endocranial and spinal surgery; in the surgery of the chest, a description of Schede's operation; in the surgery of the digestive tract, Witzel's method for gastrostomy; the use of Murphy's button in intestinal anastomosis; the consideration of retro-peritoneal tumors and of castration for enlarged prostate; a chapter on Symphyseotomy; Macewen's method of compressing the aorta in amputation at the hip-joint, etc.

The sections dealing with Fractures and Dislocations, Appendicitis, the Radical Cure of Hernia, and the more recent methods in Amputations of the Breast have been especially enlarged, particularly in the matter of treatment. Displacements of the Uterus have been also regrouped and the chapter largely rewritten.

Many of the illustrations have been redrawn, and a number of new ones have been substituted for old ones. In the present edition each illustration that is not original has been credited to its author immediately under the cut, instead of the credit being given in a List of Illustrations. The names of instrument-makers have been removed from the cuts, and credit has been given to the makers in a separate list, which will be found at the end of the Index.

WILLIAM W. KEEN,
J. WILLIAM WHITE,
Editors.

PHILADELPHIA, November, 1895.

PREFACE.

THE great advances which have been made in the Science and Art of Surgery within the last few years have created a need for new sources of reference, both for the student and the practitioner—a need which has been met to some extent abroad, but not so thoroughly in this country. For this reason the present Text-Book has been prepared by American authors who are teachers of surgery in leading medical schools and hospitals. Many of the most important subjects are considered from a new standpoint, and especial prominence has been given to Surgical Bacteriology, and to the most recent methods of treatment, particularly in relation to Asepsis and Antisepsis, and to the newer methods in those departments in which of late such notable progress has been made, as in cerebral, spinal, abdominal, and pelvic surgery, etc.

The entire book has been submitted in proof-sheets to all of the authors for mutual criticism and revision. As a whole, the book may therefore be said to express upon important surgical topics the consensus of opinion of the surgeons who have joined in its preparation, although it must be understood that, while it thus represents in general the views of all the authors, each individual author is free from absolute responsibility for any particular statement. Minor differences of opinion necessarily exist, and are recognized in the text.

The Editors assume the responsibility for the orthography, for the general plan of the book, and for the method of mutual criticism and of unsigned chapters.

Very many of the illustrations are original, among them the bacteriological colored plates and the numerous half-tone plates, which are reproduced with great fidelity from photographs of patients or of specimens, and which it is believed add to the value of the work both artistically and surgically. A large number of the wood-cuts and some of the colored plates have been taken from other authors, and are credited to them in the List of Illustrations; and the Editors desire to express their thanks, not only to the authors, but to the publishers of the various works, both American and foreign, from which these

illustrations have been taken, for their uniform courtesy and liberality in aiding their work as far as possible.

The Editors desire also especially to thank Dr. J. Chalmers DaCosta for preparing the index and for valuable aid in other ways, and Mr. Joseph McCreery for his very careful revision of the proof-sheets, and to express their appreciation of the unvarying courtesy and efficient co-operation of Mr. Saunders.

WILLIAM W. KEEN,
J. WILLIAM WHITE,
Editors.

PHILADELPHIA, August 1, 1892.

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AN AMERICAN TEXT-BOOK OF SURGERY.

BOOK I. *GENERAL SURGERY.*

CHAPTER I.

SURGICAL BACTERIOLOGY.

Bacteria or **micro-organisms**, or **microbes**, as they are variously called, belong to the lowest order of the *vegetable kingdom*, and are closely allied to the algæ. They derive their name from *βακτήριον*, a rod, which some of them resemble in shape. The developed organism is, in form, a cell, consisting of a membrane enclosing a protoplasm. This protoplasm can be strongly stained by aniline dyes. The membrane, with difficulty separated from the contents, consists of a substance closely allied to cellulose. It is not usually visible, but when treated in water its outer layer may swell and form a gelatinous envelope or capsule. During the process of division this holds the organisms together, and as they multiply may form the zoöglea or glue-like mass in which they are sometimes grouped. Many bacterial growths are highly colored, being red, yellow, or blue; according to some observers the coloring matter is in the protoplasm; according to others, it lies in granules which have been exuded—both theories are true. Many forms of bacteria possess no movement whatever, as is the case with the micrococci and the anthrax and tubercle bacilli. The great majority are at times capable of motion.

The **principal forms** of bacteria are the **micrococcus** or globular form (*κόκκος*, a berry), the **bacillus** or staff shape (**bacillus**, a little rod or staff), and **spirillum** or spiral shape.

The micrococci, when developing rapidly, are seen often in the stage of division, and, being grouped in "pairs," are called **diplococci**. When arranged in rows or "chains" they are called **streptococci** (*στρέπτος*, a chain); when bunched together in "grape-like" masses they are called **staphylococci** (*σταφυλή*, a bunch of grapes.)

These forms undergo no essential changes, although under differing conditions they may have an altered appearance. They multiply by fission, the

process being more readily observed in the cocci than in the bacilli. A number of the bacilli and a few spirilla undergo germination, spore-formation taking place within the cell before it is finally destroyed. There may be only one spore to each cell, the spore thus formed possessing an extremely dense enveloping membrane, which protects it from external influences until it can find conditions favorable for future growth. The cell is usually distended either in the middle or at one end by the spore, and when the latter has reached its full development the cell-membrane undergoes a gelatinous softening, the cell breaks up, and the spore is free. When the spore begins to develop into a bacillus it loses its tough envelope, and is then much more readily destroyed.

Bacteria are to be found everywhere, even occasionally in the interior of the healthy living tissues. They exist in the air, the soil, the water, in our clothing, on the surface of our bodies, and on the mucous membrane of the intestinal and respiration tracts. They grow best in alkaline or neutral media. They multiply under favorable conditions with great rapidity: according to Cohn, a bacillus divides into two in the space of an hour, into four at the end of a second hour, and so on. In twenty-four hours the number of bacteria derived from a single bacillus will amount to sixteen and a half millions. It is chiefly in dead organic substances that they find a favorable soil, and it is through them that the process of decomposition is carried on. Those concerned in this process are called **saprophytic** or **saprogenic**. A certain number grow in the living body, causing by their presence morbid conditions, and are known as the **pathogenic** or disease-producing bacteria. Those which produce pus are known as **pyogenic** bacteria.

Pasteur divided bacteria into *aërobic*, or those which live best in the presence of oxygen, and *anaërobic*, or those which live without oxygen. The greater portion of the bacteria are aërobic. Some are so sensitive that a slight diminution in the amount of oxygen is sufficient to prevent their development. These are called the *obligate* aërobic bacteria. Others, however, can grow well in media rich in oxygen, but are also able to grow where there is no oxygen. These are called the *facultative* aërobic bacteria. Most of the pathogenic bacteria belong to this variety, the oxygen of the body not being found in large quantities and being soon consumed by the micro-organisms in their growth. It is rare that we find a strictly anaërobic pathogenic form. An example of this variety is the bacillus of tetanus. The presence of sunlight is unfavorable to the growth of bacteria.

During the process of decomposition very powerful poisons known as **ptomaines** (*πτῶμα*, a dead body) are developed in the presence of saprophytic bacteria. They resemble alkaloids in their physiological action, and when absorbed into the body may produce more or less marked constitutional disturbance. The sepsin of Bergmann and the cadaverin and putrescin of Brieger are examples of these chemical substances. To this class probably belong the "toxines." Some of these substances appear to have an inhibitory influence upon the micro-organisms, and it is in virtue of this action that many of the artificial cultures of bacteria after a period of growth cease to develop. *Leucomaines* are animal alkaloids which result from tissue-metabolism in the body independently of bacteria. Their rôle in pathology is as yet not well defined.

It is not yet fully settled *how the bacteria act* upon the living tissues of the body: by some it is supposed that the symptoms of infectious disease are produced by the chemical substances which they elaborate as a sort of specific excretion; others believe that the phenomena of disease are produced by the changes brought about in the tissues by the organisms during their growth,

and that it is not necessary to assume the development of a particular virus. Such action of the micro-organisms will produce locally what is known as irritation or inflammation. The chemical substances produced are, moreover, diffused throughout the body, and in virtue of a ferment-like action greatly increase the tissue-metamorphosis and act also upon the thermic centres, producing fever or "constitutional disturbance." Occasionally we have an absorption of ptomaines alone, which may be introduced in large amounts, producing grave disturbances. Such a condition is known as septic intoxication or toxic infection, as distinguished from septic infection of bacteria.

The effect of the virus of certain diseases upon the tissues of the body is often such as to afford a *protection against future attacks*. This is thought by Pasteur to be due to the exhaustion of a supposed chemical substance necessary for the growth of the micro-organisms. According to Fraenkel, certain products of bacterial action are left behind after the first invasion, and prevent a return of the same kind of organism. Metschnikoff has advanced the theory that the leucocytes, seen in such large numbers in inflammatory processes, possess the power to attack and destroy the invading bacteria, taking them up into their protoplasm. He gives these amœboid cells the name of **phagocytes**. The general weight of opinion seems to be that predisposition to disease means chiefly that the tissues of the body offer a soil the chemical composition of which is favorable to the growth of bacteria, and that immunity is possessed by those tissues which furnish a soil unfavorable for their development. The chemical constitution of the liquor sanguinis is therefore an important element in the solution of this question.

Pfeffer has recently called attention to the faculty possessed by all motile bacteria of moving toward or away from certain substances which attract or repel them, and has given to it the name of *chemiotaxis*. The leucocytes and various others cells possess the same property, and their phagocytic action is but a part of the general power which they have of incorporating into themselves and then removing foreign dead or offending material. Further investigation in this direction may explain immunity in some instances.

The question of the direct *transmission* of microbic disease from parent to offspring is one not susceptible of easy demonstration. There are two routes through which hereditary disease may be communicated: through the placenta during intra-uterine life, or during the act of conception through the semen as a vehicle. Placental infection has been observed in small-pox, erysipelas, typhoid, and intermittent fever. Glanders has been transmitted in this way from mare to foal, and the bacilli of anthrax, glanders, and malignant œdema have been shown by experiment to pass through the placenta to the foetus. The tubercle bacillus has been found in the seminal fluid of consumptives not suffering from tuberculosis of the genital organs. Tubercular lesions have been found in the human foetus at varying periods of intra-uterine life. There is therefore no doubt that this disease may be transmitted from parent to child: it is merely at the present time a question of the frequency and method of transmission of the disease (Baumgarten). It is also well known that syphilis may be acquired through both the semen and placenta, although the fact that no specific organism has as yet been discovered renders it impossible to furnish the bacteriological proofs.

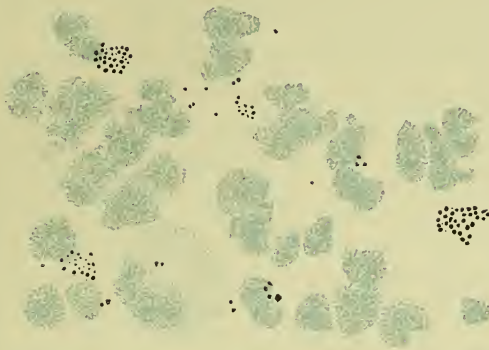
Most bacteria grow best at a *temperature* varying from 86° to 104° F. The saprophytic or putrefactive organisms prefer a temperature of about 75° F., or the ordinary house temperature. The pathogenic bacteria grow best at a temperature of from 95° to 104° F. Subjecting solutions containing bacteria to freezing temperatures does not generally kill the micro-organisms. They

all lose the power of movement and reproduction at this temperature, but may preserve the power to resume their activity at a higher temperature. Cohn has reduced the temperature of liquids containing bacteria as low as -186° F. without destroying their vitality. Cold is therefore an agent which cannot be employed to destroy these organisms. Experiments show that organisms containing spores, like the bacilli of anthrax, are much more difficult to kill than the micrococci, which do not contain spores. If dry heat is used as a means of sterilization, it is necessary to expose the latter to a temperature of 212° F. for an hour and a half in order to destroy them. Bacilli containing spores, however, must be subjected to a temperature of 284° F. for three hours before they are rendered incapable of further growth. The dry heat, moreover, does not always penetrate easily to the centre of articles subjected to this process, and most materials, and particularly instruments, are permanently injured by such high temperatures.

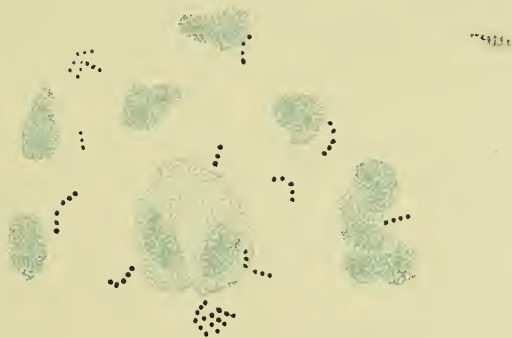
The fact that *boiling water* will kill all kinds of organisms and spores in a few minutes suggested the application of hot steam for the purpose of disinfection. Experiments showed that moist heat had in fact a much greater germicidal value than dry heat. In Koch's sterilizer all kinds of bacteria are destroyed in half an hour when subjected to a temperature of 212° F., even in those cases where the organisms were surrounded by voluminous dressings and materials of different kinds. Most of the ordinary pyogenic bacteria are micrococci, and therefore produce no spores. They are not tenacious of life, but are easily destroyed by heat. The bacilli of anthrax, malignant œdema, and tetanus, spore-bearing surgical bacteria, can practically be left out of consideration in the sterilization of surgical instruments. The following experiment shows how readily the ordinary surgical bacteria can be destroyed: Agar-agar tubes planted with a mixed growth of cocci were exposed to the action of steam in the Arnold sterilizer, and one tube was removed at the end of five minutes, a second tube at the end of ten minutes, and so on. A second series of tubes was inoculated from the first tube removed, and all of them remained sterile. No further growth occurred in the original tubes, showing that the micrococci were destroyed by the action of the steam for the minimum length of time, five minutes (A. K. Stone).

The Arnold sterilizer, which is cheap and convenient, and is in common use in America at present, furnishes a rapid and easy method of generating steam, and when in action can prepare a set of instruments for a surgical operation in five minutes' time. The short period during which the instruments are exposed to the heat renders them much less liable to injury, which is almost certain to follow longer exposure, and which has rendered unpopular this mode of sterilization among many surgeons.

The most powerful of *bactericidal drugs* is corrosive sublimate. A solution of 1 : 1,000,000 exercises a marked retarding influence upon the development of bacteria. A solution of 1 : 20,000 kills the spores of bacilli in ten minutes, and a solution of the strength of 1 : 1000, according to Koch, destroys the most powerful organism in a few minutes, without any previous preparation of the object to be disinfected. Aqueous solutions of carbolic acid, in the strength of 1 : 100, destroy in two minutes sporeless anthrax bacilli, and in the strength of 1 : 30 is sufficient for all ordinary surgical purposes, as it retards the development of the spores and kills the mature organisms. But solutions in oil have not the least influence upon the life of micro-organisms. Boric acid and salicylic acid have been regarded as useful antiseptic drugs, but their germicidal power is now known to be almost nil. Iodoform is not a germicide, but markedly retards the growth of bacteria; used as a powder, it



1. *Staphylococcus pyogenes aureus* and *albus* : a, pus-cell with nuclei ; b, free nuclei.
[*Camera Lucida. Zeiss Apochromatic objective 2.0 mm. ocular b.*]



2. *Streptococcus pyogenes* in pus : a, pus-cell with nuclei ; b, free nuclei.
[*Same power as fig. 1.*]

has a tendency to stop serous oozing, a condition favorable to bacterial growth. When moistened it liberates iodine, which has a certain antiseptic value. It does not procure asepsis of material, instruments, or wounds.

The *microscopical study* of bacteria has been greatly facilitated by the use of the Abbé condenser, which is placed beneath the object-glass and throws a cone of rays with a very broad base, thus giving powerful illumination of the section and making it possible to use higher powers which would otherwise cut off the light. By this means the section is flooded with light and the structure of the tissues is made quite transparent. If now we use aniline dyes, which stain the micro-organisms, and wash the sections afterward in alcohol or acetic acid, the coloring matter will be in great part removed from the tissues, and the bacteria alone will retain the dye. In this way the bacteria are readily distinguished from other objects, when examined with suitable lenses. For this purpose immersion lenses alone are reliable. Furthermore, contrast-stains can be often advantageously employed, by means of which the tissues are given a decidedly different though paler hue. Fragments of tissue which it is desired to examine for bacteria should be cut in pieces half an inch square and placed immediately in absolute alcohol. This should be changed once or twice, and in two days the specimen is ready for cutting. The sections are placed for five to fifteen minutes in dilute solutions of fuchsin or gentian-violet. They are then decolorized in acidulated water, and afterward washed in water; after alcohol has been used to remove the water from the specimen it is mounted in Canada balsam.

It is often necessary to examine the *urine* or the *sputa* for tubercle bacilli, for the purposes of diagnosis. The urine, which should be collected in considerable quantity, is allowed to deposit a compact sediment. A small portion of this sediment is spread upon a thin cover-glass held by a pair of forceps. It is best to let this become nearly or completely dry, and then to pass the cover-glass three times gently through the flame of an alcohol lamp in order better to fix upon the glass the material it is proposed to examine. If the sediment is light, a second or even a third drop is added, and each time evaporated to dryness. The cover-glass is now placed in the following solution, (Ziehl), which has been slightly warmed, for from five to ten minutes :¹

Fuchsin,	1 gram;
Carbolic acid solution (5 %),	80 c.c.;
Alcohol (95 %),	20 c.c.

It is then decolorized by placing it in a 5 per cent. solution of strong sulphuric acid, which removes the fuchsin from all but the bacilli. The length of time necessary for the bleaching process must be determined by experiment. The cover-glass is next washed thoroughly with distilled water, and is then placed in a strong watery solution of methyl-blue for about five minutes. The glass is finally washed in distilled water, dried thoroughly, and mounted in Canada balsam upon a glass slide. The bacilli appear under the microscope as minute red rods scattered about upon a blue background. The same

¹ *Koch-Ehrlich Stain for the Bacillus of Tuberculosis*.—1. Sections or cover-glass preparations are left in aniline-water fuchsin (or gentian-violet) solution for twenty-four hours in the cold. 2. Transfer to a solution of nitric acid (1 part to 3 of water if sections, 1 part to 4 of water if cover-glasses) for two to three seconds (just long enough to pass them through). 3. Then transfer to 60 per cent. alcohol for a moment, to complete the decolorization. 4. Wash in water. 5. A contrast-stain may be made with a watery solution of methylene-blue (if fuchsin be the first stain) or vesuvin (if gentian-violet be first used). 6. Wash thoroughly in water, dry, and mount, if cover-glasses. Dehydrate, clear in oil of cedar, and mount, if sections.

method of staining is applicable to the detection of the tubercle bacillus in the sputa of phthisical patients. A drop of the sputum is selected from one of the tough yellow clumps floating in the sputum and placed upon the cover-glass; a second cover-glass is then placed on top of it, and the sputum is pressed out into a thin layer. The glasses are then separated and dried, and furnish two specimens for the coloring process.

Bacteria are *not usually found in the healthy tissues* of the body, although occasionally they may be concealed in certain structures which show no symptoms of disease, and first make themselves manifest after the infliction of an injury or during the course of some inflammatory process. Cocci and spores may remain latent in cicatrices for a considerable length of time, awaiting a suitable opportunity for development. It is not uncommon to discover the presence of tubercle bacilli in individuals apparently healthy. An injury or a slight bruise under such circumstances would offer an opportunity for their development either as a local or a general tuberculosis. Micrococci are often found temporarily in the blood of individuals whose vital powers are enfeebled. They may disappear quite rapidly—even in a few hours—without having given rise to any well-defined pathological process.

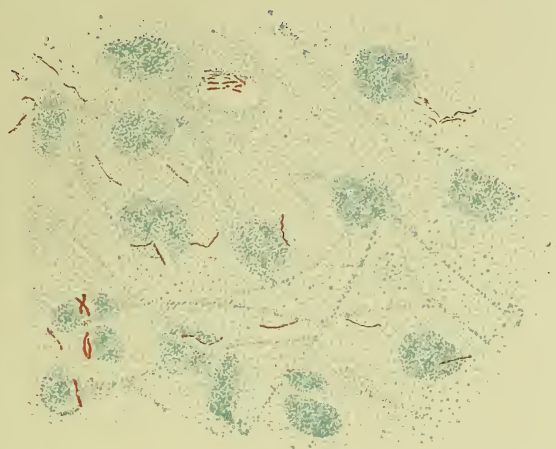
Bacteria are *found in all kinds of true inflammations*. The term “simple inflammation” is intended to designate that variety in which no micro-organisms are found. This form of inflammation is a more limited one than was formerly supposed, and is confined chiefly to those processes which follow injury and are concerned in repair if bacteria are excluded (Senn).

The *forms* of bacteria most frequently met with in surgical diseases are those which produce suppuration. These organisms are known as the pus microbes or pyogenic cocci.

The **Pus microbes** consist of several varieties, but the most common form is the **staphylococcus pyogenes aureus** (Pl. I, Fig. 1), so called from the grouping of the cocci in clusters. Its shape is globular, and it measures from 0.7 to 0.87 micromillimeters in diameter. It multiplies by division, but the line of fission is difficult to see. It is a very durable organism, and requires several minutes' boiling or steaming to destroy its power of growth. It is readily stained by all the coloring agents. It grows well at the ordinary house temperature, but is more active when growing at a temperature nearer that of the body. It does not need a large amount of oxygen for its growth. When cultivated in the test-tube upon beef gelatin it forms at first a yellowish-white layer, which later changes to an orange color; hence the last part of its name—*aureus*. If thrust deeply into the gelatin, the upper surface softens as the growth forms, and becomes liquefied in virtue of peptonizing action exerted by the organism. It has a peculiar odor of sour paste. The *aureus* is found abundantly outside of the human body. It can be obtained from dirty dish-water, the soil, or the air, particularly in foul hospital wards, but its most common seat is the superficial layers of the skin, particularly of the axillæ and other moist parts, and also under the ends of the finger-nails. It is also found in the mucus of the pharynx and digestive tract.

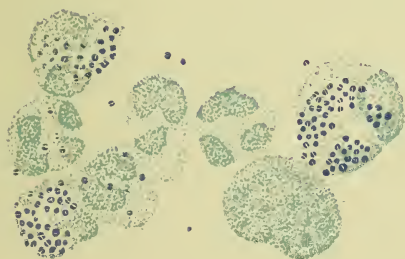
Other forms of the pyogenic cocci, but less frequently seen than the *aureus*, are the **staphylococcus pyogenes albus** and the **staphylococcus pyogenes citreus**.

The **Streptococcus pyogenes** (Pl. I, Fig. 2), is an important variety of the pus cocci. The arrangement of the organism is in chains or rows, six to ten being usually attached together. These cocci measure about one micromillimeter in diameter. On culture-media the growth reaches its development in four or five days, and has at first a transparent whitish look, but later a



1. Bacilli of tuberculosis in sputum.

[Camera Lucida. Zeiss apochromatic objective 2.0 mm. ocular 6.]



2. Gonococcus from gonorrheal pus.

[Same power as fig. 1.]



3. Bacillus tetani. Cover-glass preparation from culture by Kitasato.

[Same power as fig. 1.]

brownish color. The streptococci are found under normal conditions in the saliva, secretions of the nostrils, vagina, and urethra.

The **Bacillus pyocyaneus** is an organism which is found in green or blue pus. It is a small, thin rod with distinctly rounded ends, and unites in chains of five or six links. It has a very active motion. The pigment is deposited from the bacilli when in contact with oxygen, and is then seen principally on the exposed edges of dressings. The substance thus found is termed *pyocyanine*.

The pyogenic cocci are found in all acute abscesses. The staphylococci are found in circumscribed abscesses, as boils, carbuncles, suppurating glands, empyema, osteomyelitis, etc. The streptococci are more frequently seen in the spreading inflammations, as phlegmonous cellulitis, erysipelas, ulcerative endocarditis, and metastatic abscesses such as are seen in pyemia.

In order that suppuration should take place it is not simply necessary that the pyogenic cocci should be introduced into the living tissues. It is found that other conditions are of equal importance. Cheyne has shown by experiment that the *number of bacteria injected* is an important factor. The dose must be sufficiently large. It is owing, probably, to this fact that many cases of imperfect asepsis in surgical operations often heal well. Doses of less than 18,000,000 of the *Proteus vulgaris* when injected into the muscular tissue of a rabbit seldom cause any result, and it requires so large a number as 250,000,000 to produce a circumscribed abscess.

But the *state of the tissues* in which the organisms are arrested is also a matter of great importance. Tissues which have been damaged by injury or inflammation are not so resistant to the action of bacteria as when in a state of health. A healthy peritoneum may receive and absorb a large number of bacteria, but if damaged during a laparotomy, so that a considerable portion of its secreting surface has been destroyed and at the same time considerable oozing of blood and serum has taken place from the injured surfaces, a soil favorable for the growth of the organisms is provided and a septic peritonitis may result. Tense sutures are more likely to be followed by "stitch abscesses" than where the sutured margins of the wound come easily together.

The question has arisen, *Can suppuration take place without the presence of bacteria?* Steinhaus has shown that calomel, and also nitrate of silver, when injected into the tissues can produce pus in certain animals. Even the chemical substances formed by the pyogenic cocci, when separated from them and injected, can produce non-bacterial pus. But, as Senn remarks, the matter remains practically where it was before, as clinically we do not meet with examples of acute suppuration without the introduction of the pyogenic cocci into the system. Foreign bodies or mechanical irritation cannot produce pus without the aid of bacteria. The pus-producing power of the cocci lies in their ability to liquefy the fibrinous exudation of inflammation.

The pyogenic cocci are not usually found in *cold abscesses*. It was supposed that this form of abscess was produced by the tubercle bacillus only, but Ernst and others have found the aureus and albus in several cases of psoas abscess. It is possible that the failure to obtain cultures from this kind of pus is due to the dying out of the organism owing to the age of the abscess.

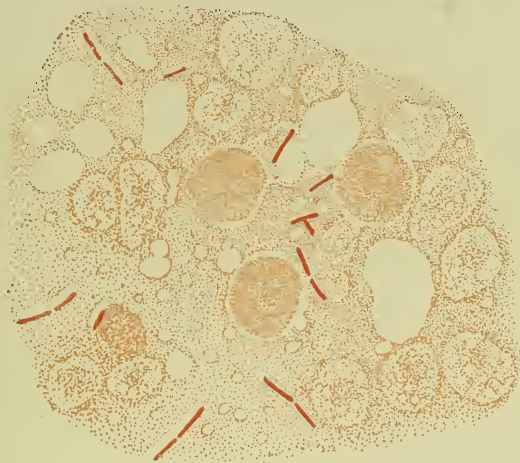
The **Streptococcus erysipclatis** resembles closely in all respects the streptococcus pyogenes, and the weight of evidence is at present strongly in favor of their identity. In all cases it is the cause of the disease, and direct proof has been given of its power by inoculation of open wounds in the human subject.

The **Gonococcus** (Pl. II, Fig. 2) is the specific organism which produces gonorrhea. It measures 1.25 micromillimeters in diameter, and is

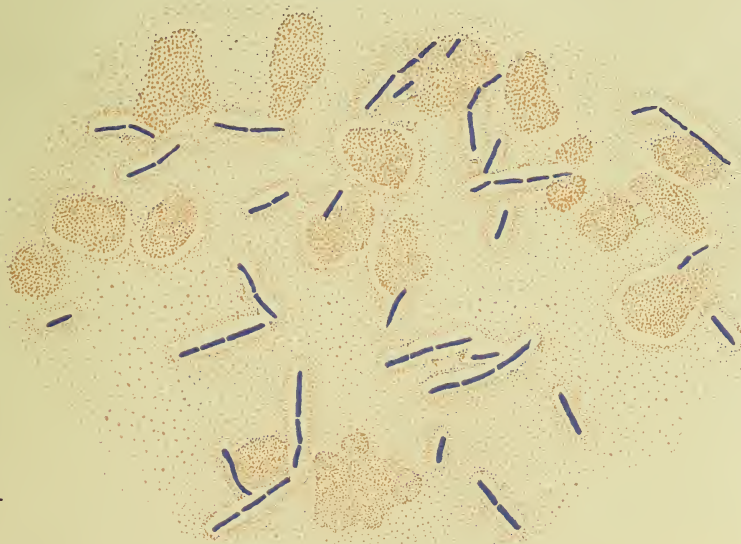
usually arranged as a diplococcus. One of the most striking peculiarities which distinguishes it from nearly all other forms of micrococci is its ability to penetrate cells and multiply rapidly within them. In this way it may be readily recognized under the microscope. It is difficult to cultivate, as it will only grow on blood-serum and when isolated from other cocci. The gonococci are stained well with methyl-blue, and may be prepared for examination by the cover-glass method mentioned previously. The organisms grow more readily on those mucous membranes which possess a cylinder epithelium or one closely allied to it, as the membranes of the male and female urethra, the uterus, and the conjunctiva. It does not penetrate below the epithelial layer, the more deep-seated suppuration, such as bubo, being due to the presence of the pyogenic cocci.

The **Tetanus bacillus** (Pl. II, Fig. 3) is a large, slender rod with somewhat rounded ends. Spore-formation takes place at the end of the bacillus, and, as it enlarges the cell considerably, gives it the so-called drumstick shape. It is movable, belongs to the strictly anaërobic organisms, and rapidly dies when exposed to the air. It is readily colored by methyl-blue and fuchsin. It can be cultivated in cultures of gelatin mixed with grape-sugar, and grows well at the bottom of the inoculation puncture, whence it sends out innumerable little prolongations, giving the growth the appearance of the fir tree. It is difficult to separate from other organisms, but several American and foreign bacteriologists have succeeded in obtaining pure cultures. The spores are found in garden soil, in masonry, in decomposing liquids, and in manure. Hence the frequency of the disease in those employed about stables. It is quite frequently met with in the dust of the streets, but owing to its anaërobic nature is not easily inoculated into the living tissues. Brieger has obtained from cultures a number of toxins, to one of which he has given the name tetanin, and inasmuch as the same group of symptoms are obtained experimentally by the toxins as by the bacilli, and as the latter are hard to find in the blood and internal organs in individuals who have died of tetanus, it has been thought probable that the symptoms of the disease are produced, in a great measure, by this substance.

The **Tubercle Bacillus** (Pl. II, Fig. 1).—This organism was first seen under the microscope by Baumgarten, but Koch cultivated and fully identified the organism with the disease in 1882. The bacilli are small, thin rods, two to four micromillimeters in length—that is, about one-half the diameter of a red blood-corpuscle. The rod is slightly bent in the middle and its ends somewhat rounded. The longest rods are usually seen in phthisical sputa. They are usually single, occasionally being found in pairs or arranged in the form of the letter V. They do not possess the power of motion. The bacillus possesses great powers of resistance to destructive agencies, the organisms in tuberculous sputa being destroyed only after twenty minutes' boiling. The expectoration can be kept for months and even years in a dried state without destruction of the bacilli. They are stained by the ordinary aniline dyes with far greater difficulty than any other bacteria, and, in common with the bacilli of leprosy, which they closely resemble, do not yield to bleaching fluids like all other bacteria. The bacilli are found between the leucocytes in the tubercles, in the epithelioid cell, and also in large numbers in the giant cell, being generally seen at its periphery. The organism is very difficult to cultivate, and grows well only on a hardened blood-serum or a combination of the ordinary nutrient media with glycerin, for which latter agent it appears to have a special predilection. When cultivated on agar the first signs of the growth appear at the end of fourteen days, and one to two weeks more pass before full development has taken place. It appears then as thick scales of a dull grayish-white color, which are very dry



1. *Bacillus* of malignant edema. Cover-glass preparation from spleen of white mouse.
[*Camera Lucida. Zeiss apochromatic objective 2.0 mm. ocular b.*]



2. *Bacillus anthracis*. Cover-glass preparation from spleen of white mouse.
[*Same power as fig. 1.*]

and brittle. The material for culture is usually obtained by inoculating a guinea-pig with tuberculous sputum. Cover-glass preparations show the bacilli growing in S-shaped or scroll-like masses.

The tubercle bacilli are true parasitic organisms, as they are unable to grow outside of the living tissues of man and animals. Inoculation may take place through the skin, following slight bruises or cuts. The organism is very resistant to the action of the digestive fluids, and animals fed experimentally with tubercle bacilli have developed general tuberculosis. It is probable, therefore, that they can penetrate the mucous membrane, and may be carried into the system with the food. H. C. Ernst has shown that *six drops* of the milk from a tuberculous cow, injected subcutaneously into a guinea-pig, may develop a tuberculosis. The milk of tuberculous cows is therefore a very dangerous article of food. The breathing of infected air is the most frequent mode of acquiring the disease. The frequency of pulmonary tuberculosis is suggestive of this mode of infection. Cornet has shown that the dust of infected localities is dangerous. The organisms are distributed through the air when in a dry state, and are found in the dust of hotels or hospitals occupied by consumptives, and in factories and prisons. The tuberculous sputa should not be allowed to dry, being harmless when kept moist. All tuberculous patients therefore should expectorate into a cup containing an antiseptic solution.

Bacillus of Malignant Œdema (Pl. III, Fig. 1).—This bacillus was first described by Pasteur, but its present name was given to it by Koch. It is occasionally found in traumatic gangrene. It is a saprophytic organism, and is found in decomposing substances and in rich garden soil. The bacilli have an active motion and contain large spores. The cultivation is attended with the evolution of gas, and when the bacilli are inoculated into animals they produce a gangrenous oedema as in man. The *pseudo-œdema bacillus* is also sometimes found in this form of gangrene, as well as the streptococcus.

In *noma*, a gangrenous inflammation of the mouth and female genitals in young children, Lingard has found long bacilli, and Ranke has found streptococci. No specific organism for *traumatic gangrene* has yet been found. It is probable that the ptomaines play an important part in the process. No bacterial examinations have been made of *hospital gangrene*, as, thanks to antiseptics, it is now almost an historical disease only. Studies made as early as 1872 show the presence of enormous numbers of streptococci, but these are unreliable from a more modern standpoint.

The Syphilis Bacillus.—It is very probable that syphilis is of bacterial origin, but the organism has not yet been satisfactorily identified. Lustgarten described a bacillus in 1884 which is slightly curved or S-shaped and is found in the tissues and discharges of syphilitic ulcers, but he was unable to cultivate it. It has been grown upon a gelatin prepared from the bladder of the Russian sturgeon. Similar bacilli have been found in the preputial and vulvar smegma. Bacilli and also micrococci have been found in the blood and tissues of syphilitic patients by other observers. Fragments of chancres have been placed in nutrient bouillon, and the bacilli thus obtained have been inoculated into monkeys, and eruptions resembling those of syphilis have been observed. All these observations require repetition and confirmation.

Bacillus Mallei.—This organism was discovered in 1882 by Löffler and Schütz in the tissues of animals afflicted with glanders. They cultivated it artificially, and made successful inoculations in animals, reproducing the disease. It is shorter and thicker than the bacillus of tuberculosis. Grown on boiled potato, these bacilli form a characteristic yellow, transparent, honey-like layer which appears on the second day. Later, the border acquires a greenish hue.

The bacilli are found grouped in the centre of the diseased nodules. Horses acquire the disease by inhalation, but man is usually inoculated through cuts or scratches.

Bacillus Anthracis.—This bacillus (Pl. III, Fig. 2) produces the disease known in man as malignant pustule and wool-sorters' disease, and in animals as anthrax. It was discovered by Davaine in 1850, and has been called the keystone to the arch of bacteriology. It is very large, being 1.5 micromillimeters in thickness and 3 to 6 micromillimeters in length. The spores when forming are seen as bright, glistening bodies in the centre of the rods. The bacilli are comparatively delicate, but the spores belong to the most durable of bacterial organisms, and are therefore generally used as a standard test of the values of disinfectants. In animals, chiefly cattle, they produce the disease known as anthrax or splenic fever, and are found in immense numbers in the capillaries of the internal organs. Pasteur succeeded in weakening the strength of these bacilli by cultivating them at high temperatures or for a long time, and thus produced an attenuated virus by means of which he was able to protect animals from the disease by "vaccination." The immunity, however, is not permanent, and does not protect against infection through the intestinal canal.

CHAPTER II.

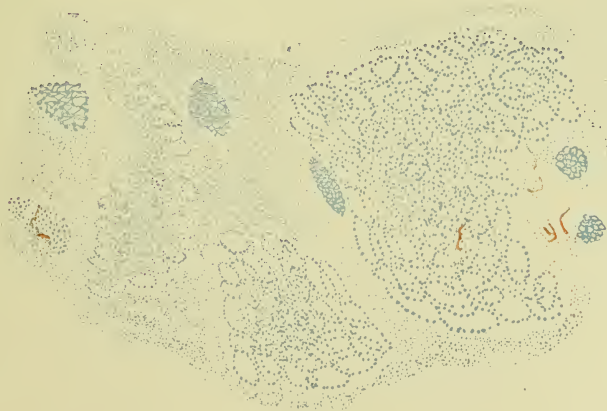
INFLAMMATION.

INFLAMMATION is a disturbance of the mechanism of nutrition, and affects the structures concerned in this function. It is "the response of living tissue to injury." It was formerly supposed to be an increased nutrition of the part, but the more modern view, as expressed by Sanderson, is that the condition is the result of damage which, if not severe enough to cause death of the part, will be followed by a series of characteristic changes in the blood-vessels and the surrounding connective tissue. As the result of this disturbance, however, we have conditions favorable for the process of repair or for the neutralization or removal of the primary microbic cause. These changes give rise to the *five cardinal symptoms of inflammation*—**pain, heat, redness, swelling, and impaired function** (dolor, calor, rubor, tumor, functio læsa).

In an acute inflammation of the connective tissue (cellulitis) we find the part greatly swollen and sensitive. The tissues also become much firmer than they were before. The skin is not only redder than natural, but is much warmer to the touch. The patient complains of a throbbing pain in the part, and if an incision is made through the skin the flow of blood is unusually rapid and copious. The function of the limb affected for the time being is impaired, and the muscles in the immediate neighborhood become more or less rigid. As the disease progresses all these symptoms are intensified, and finally at the point of severest pain the part becomes softer, an examination shows that fluid is collecting beneath the skin, and we recognize that suppuration has taken



1. Section of human tongue showing giant-cells of tuberculosis, surrounded with inflammatory tissue [submiliary tubercle]: a, muscular fiber. [*Camera Lucida. Zeiss objective DD ocular 4.*]



2. Giant-cell of tuberculosis of human tongue before stage of cheesy degenerations showing bacilli.
[*Camera Lucida. Zeiss apochromatic objective 2.0 mm. ocular 6.*]

place. The symptoms may, however, begin to abate before this stage is reached, and the part may gradually return to its normal condition. The inflammation is then said to have terminated by resolution.

In order to understand the meaning of these symptoms a study of the pathology of inflammation is necessary.

The changes seen in the blood-vessels claim our first attention. The experiments of Cohnheim in 1867 greatly increased our knowledge of this part of the process. Previous to that time the great number of cells found in an inflamed part were supposed to be due to the proliferation of the cells of the connective tissue, but Recklinghausen showed that many of the connective-tissue cells possessed the power of motion and wandered into the inflamed tissues. They are called *amœboid* cells from their resemblance to the *amœba*. Following this discovery came that of Cohnheim, who identified the cells in the inflamed tissue with the white corpuscles of the blood or the leucocytes.

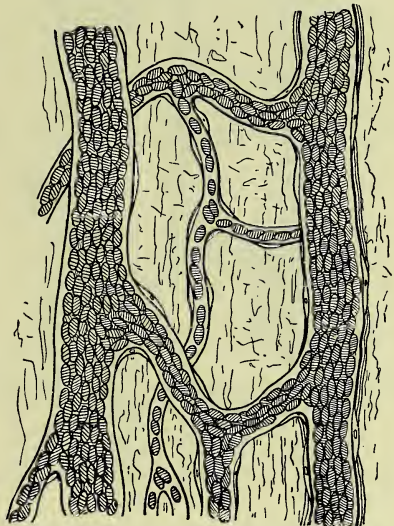
If we paralyze a frog with curare, and draw a loop of his intestine through an incision made on one side of the abdomen, we obtain in the exposed mesen-

FIG. 1.



Normal Vessels and Blood-Stream
(original).

FIG. 2.



Dilatation of the Vessels in Inflammation
(original).

tery a thin, transparent membrane, in which the circulation can be studied with ease under the microscope. It may also be readily observed in the web of a frog's foot or in the frog's tongue. The exposure of the mesentery is sufficient in itself to produce an inflammation, but an application of a caustic will be necessary, in the case of the web or the tongue, to bring about the same result. If we examine such an area under the microscope, we can generally see an arteriole with its rapid pulsating current of blood, and near by a small vein in which the blood flows with a more steady movement. The red blood-corpuscles occupy the axis of the blood-vessel, and the few white corpuscles which are seen float in the more sluggish stream of plasma which occupies the borders of the lumen and appears as a transparent layer (Fig. 1). The capillaries are not readily seen, but careful observation

will detect the channels through which, occasionally, a few blood-corpuscles pass.

At the beginning of the inflammatory process the *rapidity of the flow of blood is greatly increased* and a greater amount of blood is observed in the part. The *lumen of the artery is greater* than before, and the column of red corpuscles is much broader and fills a comparatively greater portion of the lumen of the vessel. The capillaries are now quite distinctly seen, and are crowded with blood-corpuscles. They appear to be considerably larger than they were before. The flow of blood is also more rapid in the veins, and it is of a brighter and more arterial color. This condition of the circulation is known as *hyperemia* (Fig. 2), and is presently succeeded by a *slowing of the current*,

FIG. 3.



Stasis of Blood and Diapedesis of White Corpuscles in Inflammation (original).

which soon becomes much more sluggish than in the normal state. This is first noticed in the capillaries, and soon after in the veins. The pulsation, however, continues in the arteries. As a result of this diminution of speed the column of blood-corpuscles becomes broader, and almost completely fills the interior of the vessels. In the veins a great *accumulation of white corpuscles* takes place on the interior of the walls. Being of a lower specific gravity than the red corpuscles, the leucocytes are not forced onward with the same momentum, and are dropped, as it were, here and there on the vessel-wall. Finally they are so greatly increased in numbers that the entire wall of the vessel appears to be lined with leucocytes. The white corpuscles also accumulate in the capillaries, but not to the same extent. In the arterioles these corpuscles cling more readily to the wall during the diastole, but they are soon swept away again into the blood-current.

Another step in the process, beginning concurrently with the slowing of the blood-stream, is the *emigration of the leucocytes* from the interior of the veins (*diapedesis*) (Figs. 3 and 4). Many leucocytes, by a change of shape, send out little prolongations of protoplasm into the substance of the wall, and slight protuberances are soon seen projecting from its outer surface. These enlarge, and we now see the corpuscles presenting an hour-glass appearance. The portions within the vessel soon follow those without, and the leucocytes escape from all contact with the vessel. Many corpuscles appear to follow one another through the same point in the wall. Whether there are actual holes (stomata) between the endothelial cells of the vessel through which the leucocytes escape or not is still a disputed question. The amœboid movements of the leucocytes are effected by a power of those cells to change their shape. Processes (*pseudopodia*) are thrown out from the protoplasm of the cell, which now becomes elongated or flask-shaped. As the protoplasmic mass resumes its more or less globular form, the main portion follows the protruded mass, and

a change in the position of the cell results. The white corpuscle is a minute mass of granular, or, according to some authors, reticulated, protoplasm, con-

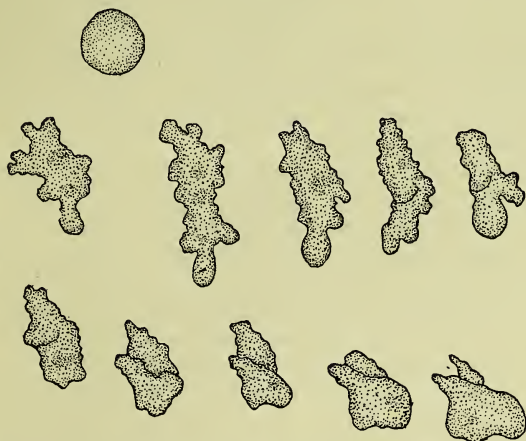
FIG. 4.



Stages of the Migration of a Single White Blood-corpuscle through the Wall of a Vein in Two Hours and Ten Minutes (mesentery of the frog; Caton).

taining one or more nuclei, and without any limiting membrane. The cells which accumulate in large numbers outside the walls of the blood-vessels in

FIG. 5.



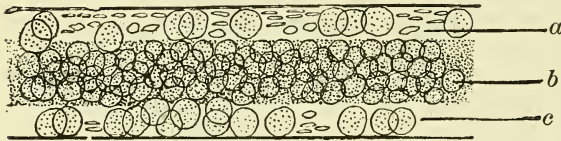
Changes seen in the Leucocyte of a Frog during Ten Minutes (original).

inflammation have the same appearance. Migration takes place to a limited extent also from the capillary vessels, but no such process is observed in the walls of the arteries.

A considerable quantity of liquor sanguinis also escapes from the blood-vessels into the meshes of the surrounding tissues, where it coagulates and encloses many of the leucocytes. When the inflammation has been severe the increased determination of blood to the part—or *congestion*, as it is usually called—is much greater; many red corpuscles may be forced through the vessel walls,

and we then find among the leucocytes occasionally a few red corpuscles. There

FIG. 6.



a, blood-plaques or third corpuscles; b, red corpuscles; c, white corpuscles (Eberth and Schimmelbusch).

is a considerable increase in the number of white corpuscles in the blood, and those organs in which leucocytes abound, as the spleen and lymphatic glands, are frequently enlarged at this time. The *third corpuscle* of the blood (Fig. 6, a), or

blood-plaque, is also frequently seen in increased numbers in the blood in inflammatory processes. This is a colorless protoplasmic disk 1.5 to 3.5 micromillimeters in diameter, numbering about one to every twenty red corpuscles (Osler). They are not visible in the circulating blood, but are found in masses as component parts of a clot. They are supposed by some to be connected with the formation of red blood-corpuscles, and are seen in large numbers at the crises of fevers and after the healing of acute abscesses.

When caustic is applied to a minute spot in the centre of the frog's tongue, we may observe all these different changes in the circulation under the microscope at the same time. At some distance from the point of irritation the circulation is normal; nearer are seen the dilated vessels, with slowing of the blood-current; next comes a zone in which a free emigration of leucocytes has taken place. As we approach the centre the circulation becomes still slower, and when we finally reach the spot where the reagent has acted directly upon the vessels, the blood no longer flows through them: this is the condition known as **stasis**. The slowing of the blood-current was regarded by Cohnheim as characteristic of inflammation. Recklinghausen, however, does not consider this a necessary part of inflammation. There is probably considerable variation in the rapidity of the current, which depends upon the amount of swelling, or destruction of tissues, or other causes which may mechanically impede the circulation of blood in the vessels. The slowing of the current seen in laboratory experiments is, according to Recklinghausen, due principally to mechanical conditions.

When blood is drawn by venesection in inflammation or fever, coagulation takes place less rapidly, and on the surface of the clot a *buffy coat* (*crusta phlogistica*) is formed. This is due to the presence of numbers of leucocytes which contain a large amount of paraglobulin and fibrin ferment. These substances, uniting with the fibrinogen found in the blood-plasma, produce the fibrin of the blood-clot. The old theory of a fibrinous crasis is thus explained.

The changes seen in the circulation account for two of the cardinal symptoms—viz. **heat** and **redness**. The rapid return of color seen after pressing the finger on an inflamed surface indicates the increased amount of blood. The copious bleeding from incisions in an inflamed tissue shows the increased determination of blood to the part and the distention of even the smallest capillaries. The bright scarlet redness is also an indication of the active hyperemia which exists in acute inflammation. In the more chronic forms, or in those in which the congestion is very intense and the flow of blood is consequently not so rapid, there is a bluish tinge to the reddened surface. If the color cannot be entirely pressed away with the finger, this is due either to decomposition of the coloring matter of the blood, which leaves a yellowish tinge behind, or, if a reddish tint remains, it is caused by the presence of red blood-corpuscles which have been forced out of the vessels by the intensity of the pressure. This "hemorrhagic" form of inflammation has often

a much deeper and more irregular coloring than is usually seen in acute inflammation. Redness is entirely absent in bloodless parts, as in the cornea, but in this case we find a hyperemia of the vessels of the conjunctiva, and later an actual development of vascular loops in the direction of the inflamed spot. It was at one time supposed that the increased warmth of the part was due to a local production of heat. It is now known that the local rise of temperature is due to the greater amount of blood which flows through the vessels.

One of the most constant symptoms of inflammation is the **swelling**. This is rarely absent, and is seen even in non-vascular parts. The increased amount of blood in the vessels of the part does not add materially to its size. We must seek for an explanation of this phenomenon in the altered condition of the tissues of the part. On making an incision into an inflamed spot we find the meshes of tissue distended with an abundant exudation, which, as we have seen, escapes through the walls of the dilated blood-vessels. The tissues are saturated with this material often to such an extent that it may be difficult for the surgeon to recognize the difference between muscles, fasciæ, and vessels. The exudation consists not only of leucocytes, but, in addition, of a certain amount of fluid which closely resembles the liquor sanguinis, and from which fibrin is formed giving a certain firmness to the part. The tissues are also crowded with leucocytes. The increased number of cells in the part was at one time attributed to the division or "proliferation" of the pre-existing cells of the inflamed tissues, but Cohnheim maintained that the new cells were the escaped white blood-corpuscles, and that the so-called fixed connective-tissue cells played no part in the process, being incapable of proliferation. This doctrine he illustrated by experiments upon the cornea. The opacity produced by an artificial inflammation was found to be due to the presence of numberless leucocytes, while the corneal corpuscles were found to be unchanged. Subsequent observations have, however, shown that the fixed cells of the cornea also undergo proliferation and take part in the process. Cohnheim thought that the immense number of cells found in an inflamed part were all derived from the white corpuscles, and that by subsequent proliferation they were increased in number and formed what is known as *granulation-tissue*, which he assumed played a prominent part in the healing process. It is a well-known fact, however, at the present time, that the fixed connective-tissue corpuscles and other cells in tissues of the body are capable of division. According to the latest views on the origin of the granulation-tissue, the round cells with single nuclei are mostly formed by the proliferation of connective-tissue and other fixed-tissue cells. Later, many of these cells, as also the leucocytes, become polynuclear cells, and as such are incapable of taking any further active part in the process. According to Ziegler, the polynuclear leucocytes appear to be taken up and destroyed by the proliferating connective-tissue cells, the leucocytes apparently serving simply as nutriment for these cells. The process of multiplication by cell-division is now much better understood than formerly, and the mode of indirect division (karyokinesis, p. 29) in which the nucleus plays a prominent part is the one most frequently observed.

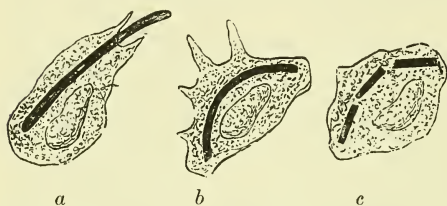
The meshes of the tissue are distended with coagulated lymph, and the connective-tissue fibres are swollen and softer than usual, and here and there terminate suddenly, as if broken off, giving them a club-shaped appearance. In the organs affected we find the epithelial cells altered in appearance, being in the condition known as that of "cloudy swelling;" that is, their protoplasm is granular and more opaque, and containing frequently fatty granules. During the development of the inflammatory process the leucocytes are seen infil-

trating the tissue between the pre-existing cells, arranged in rows or irregular masses or scattered about singly. They are more numerous in the immediate neighborhood of the small veins and capillaries. At the height of the inflammation the part may be completely filled with small round cells, many of them leucocytes and many of them derived from the cells of the inflamed part.

Various views are held as to the *function of the leucocytes*. Cohnheim regarded them as the active agents in the process of repair. By others they

have been regarded as the scavengers which appropriate to themselves the broken-down materials which result from inflammation, and thus aid in the process of absorption. Fragments of dirt or blood-clots or carmine granules, when used experimentally, are found in the protoplasm of these cells. Metschnikoff has advanced the theory known as **phagocytosis**, according to which

FIG. 7.



A Phagocyte destroying a Bacillus (Landerer).

the cells of the inflamed part, in virtue of their ability to consume foreign substances, attack and destroy the invading bacteria (Fig. 7). These cells are called **phagocytes** (*φάγω*, to eat, and *κύτος*, a cell). If they are able to destroy the bacteria, the system is protected from the invading organisms. The leucocytes are called micro-phagocytes (or microphages), and the larger cells developed from the fixed connective-tissue cells are called the macro-phagocytes (or macrophages). The latter may consume the smaller cells after their struggle with the bacteria, and thus assist in the process of absorption. A large number of experiments were performed by Metschnikoff in support of this theory. Other writers have, however, shown that the leucocytes may be the vehicles by which the bacteria are conveyed to distant portions of the body, and that they are therefore capable of spreading infection. The doctrine has not been generally accepted as an explanation of the immunity which certain animals or individuals possess against the attacks of certain diseases. The rich cell-infiltration of an inflamed part may, however, exert a protective influence in other ways. The lymph-spaces of inflamed tissue are usually crowded with leucocytes, and absorption of chemical or bacterial poison is thus prevented. The mechanical protection which the granulating surface of a wound affords is in striking contrast to the rapidity with which a freshly-exposed tissue will absorb a virus.

Returning to the microscopical changes to be seen in inflamed tissues, we find that when granulation-tissue has formed the *intercellular substance* is not so easily seen as before, and the part appears to be composed almost exclusively of cells. It is, however, rich in blood-vessels, as can be easily demonstrated by special methods of preparation. Much of the intercellular substance and many of the fibers have disappeared, and a granular intercellular substance has taken their place. This condition exists usually in the more indurated portions of the inflamed part, and gives rise to the characteristic "cake-like" hardening so often felt. In the surrounding softer and more pulpy structures we find a large amount of coagulated fibrin and serum, which latter substance may at times be excessive in quantity, and then produces a condition that is known as *inflammatory œdema*. Such collections of the fluid products of inflammatory transudations are most marked in loose connective tissues, as in the eyelids and the prepuce. When an œdematous swelling of this character takes place in the mucous membrane of the larynx fatal complications may arise.

When mucous membranes are inflamed the exudation usually shows itself in the form of an increased and altered secretion on its surface, in certain conditions even assuming the consistence of a false membrane. When serous surfaces are inflamed the transudation will take the form of an effusion into the serous cavity involved, as in the pleura or the cavity of the knee-joint. The cells which are a part of the exudation may, however, form a membrane on the walls of these cavities, and give rise to adhesions which interfere with the motion of the two surfaces upon each other.

The next symptom of inflammation is **pain**, which is due to the pressure or tension produced by the swelling upon the terminal branches of the nerves; it may also be due to exalted sensibility from hyperemia, and to the chemical irritation of ptomaines. It is most severe in the early stages of the inflammation, before the tissues have had an opportunity to accommodate themselves to the pressure exerted by the exudation. It will vary greatly with the anatomical nature of the part. In bone, where the tissues yield less rapidly than elsewhere, it will be very severe, and even in the chronic forms of inflammation the pain will be of a boring character, which is proverbially hard to bear. The throbbing pain is due to the pulsation of the hyperemic vessels of the part, and the peculiar lancinating pain which pus causes in its efforts to escape is characteristic of an abscess which is about to discharge. Pain may, however, be entirely wanting. This is the case in nerveless tissues, and also in severe inflammations which rapidly destroy the vitality of a part.

The fifth symptom of inflammation, **disturbance of function**, will show itself in various ways, according to the part affected: an inflamed muscle will become rigid and contracted; an inflamed gland will cease to give forth its natural secretion. The special senses may also be impaired, or even permanently affected, by the inflammatory process.

Inflammation *does not begin spontaneously*. Old writers recognized an idiopathic form of inflammation, but the term, if intended to mean more than non-traumatic, should be discarded. Inflammation is due to some cause which acts in an injurious or destructive manner upon the tissues, such as heat, cold, chemical action, injury or trauma, the temporary removal of blood from a part, as in laboratory experiments or in frost-bite, and, finally, infection, or the action of micro-organisms and their products upon the tissues. There is a tendency at the present time to ascribe all inflammation to the action of bacteria. According to Senn, inflammation proper should be made to embrace pathological conditions which are caused by the action of micro-organisms or ptomaines upon the histological elements of the blood and fixed tissue-cells. Hueter also believed in the universal agency of bacteria in inflammation, and regarded it as an epidemic and contagious disease existing everywhere. All other forms of inflammation would, according to this view, be regarded as the phenomena accompanying the process of repair.

The question of the *action of the nerves* in inflammation, at one time discarded, has been recently revived by Lister. It is claimed that the most striking clinical example of this type of inflammation is the so-called urethral fever which follows the use of the catheter. The inflammation of the genito-urinary tract thus brought about, and the accompanying chill and fever, are supposed to be due to a reflex action of the nerves of the part. Doubtless many of these cases may be ascribed to a septic infection by the instrument or to injury of already infected organs. The value of counter-irritation as a method of treatment is brought forward to show the probability of an abnormal action of the nerves. The so-called trophic action of the nerves in inflam-

mation was at one time regarded with favor. Division of the vagus nerve in animals was found to be followed by pneumonia. These cases are, however, now explained satisfactorily by bacterial infection following removal of the protective nerve influence of the part. The list of inflammations to be ascribed to the action of the bacteria and their products is no doubt constantly enlarging, but we are not yet in a position to discard all other supposed inflammatory agencies.

Cohnheim believed that all these agencies acted upon the walls of the blood-vessels and produced a molecular change in them by means of which the phenomena of inflammation were produced. Virchow advanced the "abstraction" theory, in which the cells of the tissues played a prominent part. Landerer does not think we ought to separate the capillaries from the tissues in which they lie in considering the seat of inflammation. When the cause of inflammation acts upon the tissues they become relaxed, the equilibrium between blood and tissues is disturbed, and we have a leakage or exudation into the inflamed part.

Most traumatic inflammations take their origin in the tissues, as these are acted upon directly by the inflammation-producing agent. Other inflammations, as the more deep-seated forms, are produced by an agent acting through the blood-vessels or the lymph-channels. In this way those types of inflammation known as parenchymatous or interstitial are produced.

From a study of the pathology of this affection we are justified in assuming, therefore, that the phenomena of inflammation are evidences of injury to the nutrition of the part, while the consequent flushing of the part with increased blood-supply, by preventing mural implantation of bacteria, and exudation, assist in the removal of injurious substances, and leave the tissues in a condition favorable to a return to the normal state.

There are several **varieties of inflammation** to be considered. Formerly the terms *traumatic* and *idiopathic* were used to designate respectively inflammation caused by injury and that which arises spontaneously; but we hear little of the idiopathic form at the present time. Inflammation may be *simple* or *infective*. The simple inflammations are limited in extent, and tend to recovery as soon as the inflammatory agent ceases to act. The infective inflammations are caused by bacteria, and have a tendency to spread.

Inflammations are said to be *sthenic* or *asthenic* according to the severity of the symptoms. The sthenic type is seen in a young and vigorous subject when affected with acute inflammation. The asthenic forms occur chiefly in old and feeble individuals. In the *parenchymatous* inflammations the part attacked is the specific cells of an organ or its parenchyma. These cells undergo a "cloudy swelling," and later proliferation may occur, or even destruction of the cells may result. An inflammation is called *interstitial* when the connective-tissue stroma which supports the parenchyma appears to be the part principally affected. We see then a cellular infiltration in the stroma of the organ. There is no essential difference in these two types, as the connective tissue is usually increased in direct proportion to the destruction of the parenchyma.

When an inflammation affects the walls of a serous cavity, we may have considerable accumulation of fluid. The term *serous inflammation* is then used to denote the type which produces a collection of fluid in the joints or the pleural cavity. The amount of serum discharged from a wound may at times be very large, and drainage-tubes are often employed to conduct away the fluid. *Adhesive* or *fibrinous inflammations* are seen best in the peritoneal cavity when two surfaces of peritoneum are quickly united by the process. The rapidity with which this membrane may become united to itself exceeds that

of any other in the body. In a few hours the adhesion will already have formed, and the peritoneal cavity may in this way be protected from the intrusion of poisonous substances such as pus or feces. The same result may be obtained in the interior of joints or the pleural cavity. The motion of the parts will stretch these new adhesions, which may thus be drawn out into bands of considerable length. When extensive adhesions occur between the opposing surfaces of a joint or in the folds of its capsule, anchylosis or great impairment of motion will result.

When bacteria are present, particularly the pyogenic cocci, these organisms exert a solvent action upon the exudation, and fibrin does not form; the tendency is therefore to a liquefaction of the tissues, and suppuration takes place. This we call *suppurative inflammation*, or, less correctly, *phlegmonous inflammation*.

Hemorrhagic inflammations occur when the red blood-corpuscles are present in unusual numbers in the exudation-fluid. This condition is found in very intense forms of inflammation, when the congestion has been extreme and large numbers of corpuscles are forced through the walls of the vessels by the unusual pressure. Black measles and hemorrhagic small-pox are familiar types, as are also some of those extremely septic forms of inflammation which the surgeon meets with. Small hemorrhages may occur in the inflammations of the aged and feeble or those affected with cardiac disease, or in scorbutic patients. The presence of blood in a serous exudation is suggestive of intense congestion of a part, as in strangulated hernia, or of the existence of malignant disease.

When a false membrane forms upon the surface of an inflamed mucous membrane the inflammation is called *croupous*. The exudation-cells and newly-formed cells of the part are caught in a fine reticulum of fibrin which forms on the surface and prevents their escape in the mucous discharges. There is more or less destruction of the epithelial cells which, when intact, exert a preventive influence against the formation of such a membrane. This form of inflammation is due to the presence of bacteria, which, as they invade the tissues more deeply, produce a sort of coagulation-necrosis of the more superficial layers of the tissues, and form what is known as a diphtheritic membrane. The principal distinction between a croupous membrane and a diphtheritic membrane lies in their anatomical situation. The former is on the surface of the mucous membrane, the latter is situated in the mucous membrane itself. There is probably no important etiological difference between the two processes.

Coagulation-necrosis is caused by arrested nutrition or by the action of chemical or thermal agencies. The changes seen in the dead tissues are due partly to a coagulation of lymph which flows into the part, and partly to a change in the cells of the part, the nuclei of which lose their power to be stained by dyes. The cells and intercellular substance become subsequently transformed into a more or less homogeneous tissue.

Gangrenous inflammations belong to the most malignant types. Death of a part may occur either from the virulence of the poison which invades it or from the great distention of the tissues by swelling, and a consequent stasis of the blood-current. The anatomical character of the tissues affected will serve as an important factor. In bone, which is unyielding, we frequently see death or necrosis of the tissue in acute inflammation.

The non-bacterial forms of inflammation have no tendency to spread. In simple inflammation the disease is confined to the part originally affected. In the infective inflammations we find the tissues involved for a considerable

distance from the original starting-point. In mucous membranes the inflammation has a tendency to spread along the surface rather than to deeper parts, and the same is true of inflammation of the skin. In the phlegmonous types of inflammation the process will involve deeper parts, and the subcutaneous connective tissue may become the seat of abscesses. Dense fasciæ and bone may resist the invasion of the inflammatory process, but the softer tissue of the interior of bones is a frequent seat of infective inflammations.

Not only will the part attacked feel the influence of the inflammatory agent, but the whole system may be affected, and we then have what is known as constitutional disturbance—*i. e. fever*. The nature and extent of the febrile process depends upon the materials which are taken up and absorbed from the inflamed area.

In *chronic inflammations* the symptoms are much less marked. The swelling is only moderate in amount, and there is very little increase of temperature. There will be some pain, of a neuralgic or boring character according to the locality of the part, but it will not be continuous, as in the acute form. Microscopically we find an abundant connective-tissue growth, containing a large amount of fibers, but comparatively few cells. Many degenerative changes are seen in such tissues: the fibers are often transformed into a gelatinous transparent tissue, and they appear to have been absorbed or destroyed. The number of leucocytes in such forms of inflammation is probably small, and the new cells found in the tissue are probably derived chiefly from the fixed cells of the part. We find degenerative changes in their nuclei and protoplasm, and also evidences of proliferation of the cells going on at the same time. Here and there we see clusters of granulation-cells with epithelioid and giant cells. In other cases a dense fibrous tissue is formed, or, in bone, bony growths which lead to an hypertrophy of the part. The causes of this form of inflammation are malnutrition of the part and a continuous action of the inflammatory agent. Loss of nerve-supply by section of the nerve or injury to the spinal cord so diminishes the vitality of the tissues that the slightest injuries give rise to inflammation. Repeated slight injuries will also produce a chronic inflammatory process. The most frequent causes are the chronic forms of bacterial disease, such as syphilis or tuberculosis. The results of such inflammation may lead to adhesion in joints or thickening and deformity of bones. A class of swellings known as the granulomata are produced by the bacterial growths. Chronically inflamed parts are often much discolored and pigmented, and slight injuries may lead to ulceration which heals with difficulty.

Subacute inflammation is a term used to denote a type intermediate, in regard to the severity of its symptoms, between acute and chronic.

Inflammation may *terminate* by resolution, suppuration, gangrene, or tissue-production. *Resolution* implies that the various symptoms gradually subside, and the part will return to its normal condition without any appreciable alteration of its tissues. The granulation-tissue which has formed will gradually disappear by absorption of the leucocytes and effused lymph. Many of the leucocytes return into the circulation through the lymphatic vessels and the capillaries and veins; others are broken down and disintegrated. The same fate meets also the proliferated cells of the part. New fibres are formed in the place of those which have been destroyed during the inflammatory process, and the injury done to the tissues is thus repaired. With the absorption of the products of inflammation the inflammatory agents also disappear.

When *suppuration* takes place there is a loss of substance, and after the pus has been discharged a more extensive process of repair is needed to produce a healing of the wound and the formation of the cicatrix.

Very severe forms of inflammation will lead to *gangrene*. The dead tissue is gradually separated from the living, to which it is attached, by the formation of a line of demarcation—that is, by suppuration—and when the slough has separated healing by granulation takes place. As absorption takes place, the red blood-corpuscles found in the exudation are broken up and part with their coloring matter, which remains behind and frequently produces pigmentation. Many of the cellular elements undergo fatty degeneration, which may occasionally occur on so extensive a scale that the material is not all absorbed, but remains behind as masses of cheesy degeneration. In some cases lime-salts are eventually deposited in the unabsorbed material, and calcareous concretions are formed. *Tissue-production* is considered in the next chapter.

Treatment.—The principal method of treating inflammation a generation ago was the so-called antiphlogistic treatment. This was based on the theory that inflammation was an inflammable condition of the part, which, like a fire, must be subdued by appropriate measures. It did not take into account the causes of the process, which are now so much better understood. This method consisted in the use of emetics, venesection, cupping and leeching, and the administration of drugs, like mercury, which were supposed to have an antiphlogistic tendency. This method has given place to antiseptic treatment, which has the important advantage of dealing directly with the cause of disease. Some of the older measures are, however, still retained, and may occasionally be used to advantage in relieving some of the symptoms of inflammation.

LOCAL TREATMENT.—*Venesection* is an operation rarely seen at the present time, and may be said to have been wholly abandoned as a surgical therapeutic measure. The local abstraction of blood under certain conditions may, however, be used to advantage. Nancrede has attempted to formulate these conditions. He has shown by study of the microscopical changes in the web of the frog that removal of blood from the venous side of the circulation produces an increase in rapidity with a lessened force in the circulation of the part, and favors an absorption of the exudation. The use of drugs, like ergot, which constrict the arterioles he regards as harmful at this stage, as tending to produce stasis; but such remedies might be given with advantage during the preliminary stage of hyperemia.

In cases of extreme congestion, where there is danger of death of the part from a general stasis, the use of *leeches* is of value, as also frequently in less severe forms, when the removal of pressure brings with it great relief to pain and assists in bringing about that natural termination of inflammation—resolution.

As the majority of surgical inflammations are of a septic nature, the antiseptic treatment will be the more rational method to pursue in most cases. This method will be described in its appropriate place, as also the aseptic treatment, which may be regarded as the prophylactic treatment of surgical inflammation.

Counter-irritation was another of the weapons of the antiphlogistic system, but, although much less used at the present time than formerly, has not been wholly discarded. It is a remedy of more value in chronic inflammations than in those of an acute type, and may act, possibly, through the nerves of the part by a reflex process, and thus produce a change in its nutrition and promote absorption. The actual cautery is still occasionally used in deep-seated inflammation of the joints. It should be lightly applied at a white heat over a considerable extent of skin near the inflamed part, and should act only on the superficial layers of the skin. Repeated blistering is also of benefit in producing absorption in an enlarged gland or a “weeping sinew,” or

of an exudation which is slow to disappear. Iodine may be used for the same purpose, but probably acts in virtue only of its power to produce a local irritation on the surface, and not from any special sorbefacient quality possessed by the drug itself.

Compression is a valuable agent in the treatment of both the early and the late stages of inflammation. In the acute stage it restrains the tendency to excessive swelling of the part and the collection of serous or bloody discharges between the lips of a wound. It must be applied, however, with great care during this period, as sloughing or even gangrene may be the result of tight bandages on a part when the circulation is enfeebled by injury. In the later stages compression may be employed with great advantage, and is one of the most valuable agents which the surgeon possesses to promote absorption and resolution. It is most useful in chronic inflammation. The beneficial effect of pressure upon a varicose ulcer by plaster or a rubber bandage is an admirable illustration of this power, as is also the effect produced upon the serous effusion in a knee-joint by elastic bandages made of rubber or flannel. A most efficient means of obtaining compression of the knee-joint is with compressed sponge: two coarse sponges may be flattened over-night under a heavy piece of furniture; one is put on either side of the joint, which is placed on a posterior splint; a long cotton bandage is now firmly applied, after which a stream of water is allowed to trickle into the sponges. This dressing may be left on for one or two days, sufficient moisture being supplied to keep the bandages tight.

Cold and heat are used for the purpose of reducing the hyperemia and to relieve pain. *Cold* may be applied either by evaporating lotions or by the use of ice. Evaporating lotions can be used on exposed parts, but must be changed very frequently to have the desired effect. They are less used than formerly. Ice may be applied in thin rubber bags. Cold can also be applied by the "ice-coil," by means of which a current of ice-water is allowed to flow through a coil of rubber or metal tubing over the part. Care must be taken to avoid freezing the superficial layers of the skin if a prolonged use of the remedy is intended. The ice-bag is comforting in cases of rapid swelling following injury, to a tender and swollen knee-joint, or to an inflamed throat. It is dangerous in cases of extreme congestion, as in strangulated hernia.

Heat may be applied in the form of fomentations, hot-water bags, or the hot douche. It acts, doubtless, in various ways. A hot fomentation when first used produces a powerful counter-irritation; later, it acts through the circulation, relieving stasis and favoring an absorption of exudation. If the heat be maintained at a high point by frequent application of the hot douche, a constriction of the blood-vessels takes place, and congestion is thus diminished. The flax-seed poultice is now discarded in the treatment of wounds, but may still be used with advantage when no wound exists. The antiseptic poultice, now used for wounds in certain cases, is practically a hot fomentation to which some antiseptic agent has been added.

Incisions are often of great value in certain types of inflammation, even when suppuration has not taken place. In cases of intense congestion of the inflamed part, when the integuments are thick and brawny, one or more incisions are followed by a free gush of blood and serum which greatly relieves the tension of the part and wards off not only threatening deep-seated suppuration, but also gangrene of the parts. The incision should be made completely through the skin and cellular tissue, but should not be over two inches in length in most cases. Early interference of this kind is imperatively needed in the rapidly spreading forms of inflammation such as occur often in the hand and forearm, which may not only ruin a hand, but endanger a life.

Elevation of the inflamed part, combined with rest by splints, etc., is of the utmost importance in controlling the progress of an inflammation. Other remedies will be of little use if the congestion is favored by allowing the limb to be dependent, and if motion is permitted to interfere with the natural tendencies toward resolution and repair.

Physiological rest of injured as well as of internal organs is also indicated, to enable the disturbed function to be restored. The importance of absolute rest after injuries to the brain has long been recognized. A chronic cystitis may be cured by cystotomy when all other remedies have failed.

Parenchymatous injections were proposed at one time to arrest the progress of bacterial infection. Hueter employed 3 per cent. solution of carbolic acid in this way around the area of erysipelatous inflammation. This method, in general, has not met with favor. It is possible, however, that the hypodermatic syringe may have a future in surgical diseases which is not yet apparent.

The results of inflammation which remain in the shape of stiffened joints, contracted or enfeebled muscles, and thickened integuments can best be dealt with by *massage*, which not only favors absorption, but is a powerful restorative of the physiological action of the part.

CONSTITUTIONAL TREATMENT.—It is essential to remember that local treatment, whatever its nature may be, is not the only method to be employed to restore the patient to health. The careful surgeon will always pay due attention to the general condition of the patient. The presence of organic disease elsewhere must not be allowed to pass undiscovered.

Stimulants may be used during the progress of the fever to sustain strength. Alcohol can be used freely in all cases where there is an abnormal consumption of tissue, whether the result of acute febrile disturbance or of chronic wasting disease. Here alcohol becomes a food, and one of the most valuable kind. Patients who cannot bear the usual doses of alcohol often experience benefit from minute quantities. Dram doses of whiskey are often well borne, and are of service in such cases. In the "typhoidal" state which accompanies profound septic infection astonishingly large quantities will be assimilated even by patients unaccustomed to its use. Flushing of the face is an indication that the dose should be diminished in quantity. Champagne is a good substitute for whiskey or brandy where the stomach is sensitive. Beer and ale are useful during convalescence or in chronic types of inflammation.

The use of *antipyretics* has little permanent influence on the pyrexia, and does not appear to give that relief to symptoms which is obtained by it in so-called medical diseases. A much more reliable method of controlling the constitutional disturbance is careful attention to the local conditions of the wound or inflamed part.

A large variety of medicines have been used in former times on account of their supposed virtues in arresting or shortening the inflammatory process. Among these may be mentioned quinine and mercury. *Quinine* is still much used, on account of its tonic action even during the febrile state. Its employment in large doses of 20 grains or more is confined chiefly to malarial regions, where perhaps there is a tendency to use it to excess. In doses of 5 grains it may be given, three times a day, in any form of fever in which a tonic effect is desired. It is still used largely in erysipelas.

Mercury was formerly used internally in every form of inflammatory process, on the theory that it had a powerful antiphlogistic action. It was supposed to dissolve the fibrinous exudation. Much of its reputation was probably due to the effect it had upon unrecognized forms of syphilis. Calo-

mel, in which form it was usually administered, has now given place to corrosive sublimate, which as an antiseptic takes the highest rank. Calomel may also have exerted a beneficial effect in virtue of its cathartic action.

Purgatives were used freely as part of the antiphlogistic system of treatment, and are still valuable in certain forms of inflammation. They are part of the routine treatment of head injuries, and, if administered promptly in coma following these injuries or in apoplexy, are supposed to remove sources of irritation and to leave the system in a condition unfavorable to meningeal or cerebral inflammation. Six grains of calomel placed upon the tongue is an easy means of acting upon the bowels under these circumstances. The dose may be followed in two hours by an aloes enema (one dram of powdered aloes to a pint of hot soapsuds). Such a mode of treatment is supposed to exert a "derivative" action, by means of which irritation is removed from the brain and its coverings to distant parts of the economy. The tendency to hyperemia is in this way diminished. The treatment of peritonitis by purgatives, particularly after laparotomy, has lately come into vogue. It seems to be based upon the power of the cathartic to remove gas, and consequently to relieve the tympanites, and by its production of watery stools also to relieve the engorgement of the intestinal vessels, and eliminate germs or ptomaines by causing the emptier vessels to absorb the peritoneal exudates. A Seidlitz powder or a dose of Epsom salts will often promptly remove alarming symptoms. Smaller doses of salts, repeated every hour or half hour, may be substituted for the single larger dose.

Diaphoretics, although but little used in surgery, may occasionally be found of value, owing to their antipyretic action. Water can almost always be given freely if taken in small quantities from time to time. Sweet spirits of nitre in dram doses, when largely diluted in water, will favor diaphoresis, and at the same time is useful as a sedative and also as a diuretic.

The importance of *diuretics* in inflammation of the bladder need not be insisted upon here. Their value will be discussed in another chapter.

Emetics have long since been discarded as a means of controlling inflammation, though they are useful when the stomach is overloaded. They were formerly used in connection with venesection.

Anodynes are of the greatest value in the treatment of inflammation. They relieve the most disagreeable symptom of inflammation—namely, pain—and also the malaise and nervous disturbance which are the accompaniments of fever. First among these is opium, which not only relieves pain, but contracts the peripheral vessels. The crude drug is rarely given except in a suppository. Morphine is on the whole the most useful of its derivatives. The subcutaneous injection of morphine should be reserved for the more acute forms of pain. It is well to avoid the habit of giving the alkaloid in this way too freely, as it is a powerful remedy, acting with double the power of the same dose when given by the mouth, and is sometimes followed by symptoms of collapse or opium narcosis. The liquor morphinæ sulphatis (gr. j to ʒj) can be given by the mouth in teaspoonful doses, and repeated every hour or half hour until pain is relieved. If it is desired to avoid the disagreeable effects of morphine upon the stomach, it can be given by suppository. This is an exceedingly convenient way of administering opium for pain in any part of the body. The relief from pain brings with it rest—a most important element in the treatment. The production of obstinate vomiting by even the smallest dose of opium or its derivatives is of occasional occurrence. It is usually a personal idiosyncrasy. In important cases its possible existence should not be lost sight of. The nervous disturbance will be also relieved by this drug, but we must

rely more upon chloral, the bromides, sulphonal, or other hypnotics for the relief of this symptom and to obtain sleep.

The *diet* is of the greatest importance in all forms of inflammation. The fallacy that low diet is necessary under these circumstances is now well exposed. The stomach should be supplied with food of the most nutritious character, but in a form that can be easily digested. Milk is the most valuable of all liquid forms of food. It may be given pure, mixed with lime-water, peptonized, or sterilized, or it may be taken in the form of gruel. Alcohol may be given with it. A very excellent combination is wine-whey. Clear beef-tea has but little nourishing power. Meat-broths are, however, nutritious and valuable articles of diet for the sick. Pure beef-juice is a most reliable form of concentrated and digestible nourishment. When food cannot be taken by the stomach, enemata may be given by the rectum. These may consist of beef-broths, with or without brandy. Some of the various peptonized forms of meat may be found useful for this purpose. A few drops of laudanum may be given with the enema when there is any difficulty in retaining it.

After the inflammation and fever subside the solid forms of food may be used more freely. Light wines or beer can be used if any alcohol be needed at this period. Tonics are now indicated, as iron, quinine, calisaya-bark, and the phosphites. They improve the appetite and favor the local process of repair and the return of the system to a normal condition.

CHAPTER III.

THE PROCESS OF REPAIR.

It was formerly supposed that inflammation was necessary for the healing of a wound, but from the present point of view the processes of inflammation and repair are regarded as distinct from one another. Under the condition of asepsis we are now able to see wounds heal without the usual phenomena of inflammation. The symptoms of inflammation are brought about by the disturbed functions of tissues which have been damaged. Repair, on the other hand, is the result of an active process by means of which the cells of the part are enabled to replace tissues which have been destroyed.

Healing of a wound is said to take place either by first intention or by second intention.

In healing by **first intention**, or primary union, repair takes place without suppuration. When an incision is made through the skin and superficial tissues, the edges of the wound separate from one another according to the elasticity of the different structures which have been divided: the wound is said to gape. The bleeding of the smaller vessels soon ceases spontaneously, owing to the contraction of their lumen and to the retraction of the arterioles into their sheaths, where they are soon obstructed by the formation of a clot. The largest vessels are controlled by pressure, torsion, or ligature. When the blood has been washed or wiped away the edges of the wound are carefully adjusted by means of sutures. If such a wound has been kept perfectly aseptic—that is, if no bacteria have been allowed to gain access to it—we shall see but little change in the appearance of its edges during the healing process. There will be a slight swelling of the lips of the wound, and the tissues in the immediate neighborhood of the linear incision and around the stitch holes will be some-

what firmer than in the natural state. This is due to the disturbance in the circulation owing to division of the vessels, and to the injury done to the tissues. There is no redness, as hyperemia is usually absent, but a moderate amount of exudation occurs, which results in the formation of fibrin, by means of which the surfaces brought in contact are temporarily glued together. In large wounds the amount of exudation may be considerable, and, unless it be conducted off by a drainage-tube, may accumulate in spaces which have not been accurately brought in contact, and thus separate the opposing surfaces. In order to avoid this either buried sutures or pressure must be employed to keep the raw surfaces of the wound in contact, or a drainage-tube must be inserted to conduct off the exudation, and thus allow the raw surfaces to adhere.

It was at one time thought that the edges of a wound might unite by what was called immediate union—that is, by an adhesion of the microscopical structures of the part, without any reparative effort. It is now known that such a union is merely the temporary adhesion of fibers to fibers by means of fibrin, which is preliminary to final union by the formation of new tissue.

In all large wounds, no matter how careful the adjustment of the parts has been, there are always places where the walls have not come accurately in contact. If we examine under the microscope a wound healing by first intention, we find these small spaces occupied by blood-corpuscles and masses of coagulated fibrin. There will also be found some fragments of bruised and injured tissue, and here and there small portions of tissue which have undergone a necrosis owing to the impairment of their blood-supply. At the end of the first twenty-four hours there will be an accumulation of leucocytes along the line of the wound. The number of these cells is usually small, but when inflammation is present to any extent they may accumulate in sufficient numbers to obscure the pre-existing elements of the tissue. At this period the vessels are not seen near the margins of the wound, but Thiersch has shown by injection preparations that a system of plasma-canals exists, which communicate directly with the adjacent vessels, and that many of the red blood-corpuscles and masses of fibrin, apparently extravasated in the tissues, lie in these spaces, which thus are able to provide nutriment to the part until new blood-vessels are formed. As the process of repair proceeds the number of cellular elements of the part—*indifferent cells*, as they are called—increases perceptibly (Pl. V).

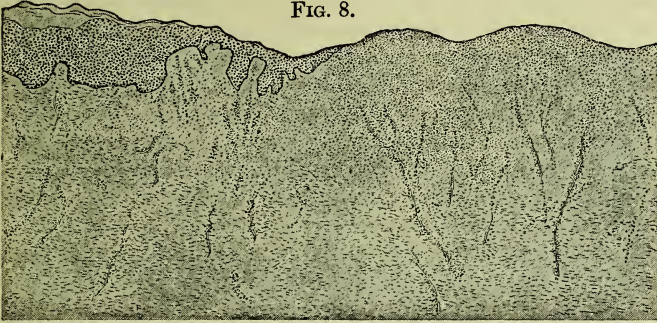
As the cells increase the fibers of the old tissue become more obscure, and many of them, and of other elements which have undergone retrograde changes, disappear, and the cells seem soon to be supported in a new granular or fibrillated or reticulated intercellular substance, and the so-called **granulation** or **embryonic tissue** is formed. At first this is composed of round cells; in the course of a few days, however, a large number of spindle-shaped cells are found mingled with these, and other large cells with one or more nuclei, which are called epithelioid cells. A high-power microscope will show, in fact, the greatest variety of shapes at this time. Later the spindle-shaped cells become more numerous, and the new tissue begins to present a fibrous appearance. The origin of the cells of the granulation-tissue is a subject about which there has been much dispute. According to Cohnheim, these cells are the emigrated leucocytes, which are able by proliferation to produce other cells like themselves, and are the active agents in the formation of the new tissue. The view that the fixed cells of the connective tissue and the parenchyma cells of organs are able to proliferate and form new cells during the process of repair has been gradually regaining its lost position, and the very latest views are as follows:



Left margin of wound healing by first intention on the 3d day : *a*, epidermic layer showing cells undergoing karyokinesis ; *b*, leucocytes accumulating on the edge of the wound ; *c*, blood-clot filling dead space—commencing “organization ;” *d*, vein from which leucocytes are emigrating.

Granulation-tissue contains many leucocytes, but they take no active part in the healing process, serving simply as food for the other cells as soon as they have reached a certain stage in their career, known as the polynuclear stage, a point beyond which they are unable to develop. The cells coming from the proliferating tissue-cells are the constructors of the new tissue, and they have in early life amœboid movements (Ziegler). It is not possible to distinguish the two kinds of cells in granulation-tissue, and when cells of either kind become polynuclear they are no longer able to take an active part in the growth of tissue (Grawitz). It is proposed by Marchand to call the leucocytes found in granulation-tissue "exudation-cells," and the proliferating connective-tissue cells the "formative cells." Soon after the first day of the healing

FIG. 8.



Wound healing by Granulation (original).

process new vessels begin to form in loops which develop from the pre-existing vessels. On the surface of a capillary loop a mass of granular protoplasm is seen, which gradually increases in size and grows to an elongated mass of solid nucleated protoplasm which projects toward the edge of the wound. These prolongations either become attached to the wall of another vessel, or unite with similar outgrowths from other vessels or with the cells of the surrounding tissue. Later, the central portion of these newly-formed structures melts away, and they become hollow and establish a communication with the vessels from which they spring. The wall of the new vessel is at first homogeneous, but later becomes nucleated and lined with endothelium. In this way a mass of capillary loops form on either side of the wound, eventually becoming united and forming an exceedingly rich capillary network in the new tissue. As cicatrization completes itself many of the spindle cells and round cells disappear. Some undergo granular degeneration and are absorbed; others wander into the adjacent lymph-spaces, and are taken up again into the circulation; many, after reaching a certain stage of development, are destroyed by the more active cells in the reparative process. As the cells vanish new fibers make their appearance, and the wound becomes thus firmly united. In the mean time, on the surface a clot or crust of broken-down blood-corpuscles, epithelial scales, and exudation-material has formed, underneath which new epithelium develops from the deeper layers of the rete mucosum which covers in the surface of the wound.

When from loss of tissue or other cause it has not been possible to close a wound, and the lips are separated widely from one another, union can only take place by the process of healing by granulation, or **second intention** (Fig. 8). If we watch such a wound with the naked eye we shall observe, in the course of an hour, that a film has formed upon the surface; the wound has become glazed by the deposition of a thin layer of coagulated fibrin. This layer, at first transparent, soon becomes stained with masses of coagulated blood and fragments of

fibers torn from their surroundings and lying upon the surface. This layer is also soon occupied by numbers of emigrated leucocytes. In this way the wound is covered over so that the structures beneath can no longer be recognized. The discharge which flows from the wound is at first of a reddish hue, and consists chiefly of bloody serum in which are floating fragments of broken-down tissue. This gradually changes to a grayish color, and is found to contain more white corpuscles and fewer red corpuscles as time goes on. In a few days the dirty layer covering the surface of the wound is washed away by the discharge, which has now assumed the yellowish-white or creamy color of pus, and the wound is said, in surgical parlance, to clean off. As the débris is swept away we find underneath a surface of bright and irregular-shaped nodules which are called **granulations**. The time which granulations take to form may vary from two or three days to a week, according to the health of the individual or the nature of the tissue involved. Microscopically, the tissue consists chiefly of small round cells mingled with epithelioid or larger cells, such as are seen in the so-called granulation-tissue, the origin of which has already been described. The velvety appearance of a granulating surface is due to the little elevations on the surface produced partly by growth of cells near the blood-vessels and partly by the œdema of certain portions of the tissue.

The cavity of the wound is gradually obliterated, partly by the growth of the granulations and partly by cicatricial contraction by which the edges of the wound are approximated. In the mean time the epidermic cells by proliferation begin to cover in the margins of the open surface of the wound, and a thin bluish-white border indicates the presence of a fresh epithelial cell-growth. New formation of epithelial cells cannot occur in the center of the wound unless some fragment of epithelial structure, such as a portion of a papilla, sweat-ducts, or hair-follicles, may have remained, from which such an outgrowth could take place; hence cicatrization always progresses from the circumference toward the centre. Occasionally the growth of granulations is so exuberant that they project above the surface of the skin, and the epithelium may then be unable to cover in all the surface. This "proud flesh," as it is popularly called, must be removed with the knife or caustic before the healing process can be completed. Healing may take place by direct union of granulating surfaces, or "*healing by third intention*." It readily occurs in wounds rendered aseptic and kept so by the use of iodoform or sterilized gauze. The gauze being removed on the second or third day, the surfaces from which little or no secretion exudes are brought in apposition and unite.

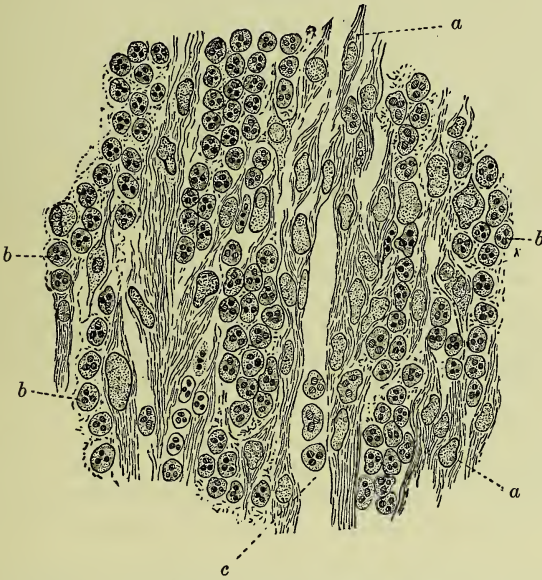
After the *cicatrix* has freely developed, it consists of fibers interwoven in various directions possessing great contractile powers, which cause many of the delicate vessels to disappear and the red scar to grow pale. In extensive scars this contraction gives rise to great deformities, particularly when the wound is situated in regions where two adjacent portions of the body may be thus bound together by a dense scar. Examples of this may be seen after burns on the neck or at the flexures of the joints (see *Burns*).

Granulations are not always firm and red: occasionally they are pale and flabby, which appearance is due to an unusually œdematous condition. These are often seen in tubercular processes. Erethistic granulations bleed easily and are excessively painful. They appear to be caused by some mechanical disturbance of the wound. The surface of the wound will sometimes be found covered with a membrane which has a diphtheritic appearance, and is caused by imperfect development of the capillary vessels or is due to their obstruction by inflammation. A coagulation-necrosis of the upper layers of the granulation is thus produced.

The healing of subcutaneous wounds does not differ essentially from the process already described. Repair, however, usually takes place without suppuration. In this case we find the seat of the wound occupied by a blood-clot, sometimes of considerable size. As repair progresses the extravasated blood is gradually absorbed, and granulations push out from the surrounding connective tissue and ramify in the clot, which furnishes a favorable culture soil for the new cell-growth. The amount of inflammation which will accompany this process depends upon the degree of injury or upon bacterial infection. In the case of infection by sloughing of the integuments or of intravascular infection, suppuration will take place and an abscess will form.

The same mode of healing under a blood-clot occurs when an open sterile wound has been filled with an aseptic blood-clot which is allowed to remain. The layer of clot which covers the surface becomes hard and dry, and gradually loses its dark color. As the clot shrinks the epithelial margins follow close upon its edges, while the connective tissue-growth beneath has been substituting itself for the fibrin and blood-corpuscles which are gradually absorbed. When the wound has healed the remains of the surface clot break up and come away with the dressings, and a firm cicatrix is disclosed. If infection of the wound has taken place, the clot will break down and be swept

FIG. 9.



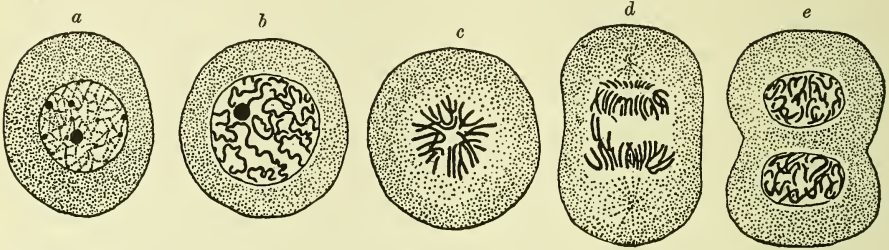
Process of Repair of a Wound: *a*, cells forming connective-tissue; *b*, leucocytes; *c*, newly-formed blood-vessels (original).

away with pus which forms, and the wound will then heal by granulation. This method of healing by organization of the blood-clot, as it has been called, is the one which usually occurs in ruptures of the internal organs, such as the liver or the kidneys.

The formation of fibrillar connective tissue is accomplished by the proliferation of the fixed cells of the connective tissue. Cell-division takes place either directly or indirectly. **Direct cell-division** (Fig. 9), which is simply a segmentation of the nucleus followed by a division of the whole cell, was thought to be the ordinary mode of cell-growth, but the **indirect method** is the one which usually occurs. This latter is known as **karyokinesis** (Fig. 10). When such

a mode of cell-division is about to take place, the delicate reticulum of fiber of which the nucleus is composed when in the quiescent state—and which is called chromatine substance, from its capacity to take staining fluids—becomes con-

FIG. 10.



Karyokinesis, or Indirect Cell-division (Ziegler): *a*, cell with nucleus in quiescent state. The nucleus contains nucleoli and a network of threads; *b*, formation of coarse chromatine threads in nucleus; *c*, disappearance of nucleolus and membrane of nucleus; arrangement of threads in loops forming the "rosette"; *d*, angles of loops directed toward the poles of the cell, which are formed of achromatic threads; *e*, beginning division of the cell; this is followed by a gradual return of the nucleus to the quiescent state (*a*).

verted into a skein of contorted filaments, which gradually assumes the shape of a rosette, and subsequently a star. Meanwhile the wall of the nucleus has disappeared. In a later or equatorial stage of the process the star-shaped mass of filaments separate into two groups, which dispose themselves around the two poles of the nucleus, leaving a clear space in the plane of the equator. When the nucleus has thus divided the filaments return to their former quiescent state. The protoplasm is contracted along the line of equatorial division, and the division of the cells becomes complete (Quain). The new cells, or *fibroblasts*, as they are called, become elongated by the formation of prolongations from their extremities, and, as shown above, develop fibrillæ by a differentiation of their protoplasm.

Examples of *wounds of bloodless tissues* are seen in the cornea and in cartilage. When the cornea is divided and the wound gapes, it is filled in at first partly by a coagulum of fibrin, and partly by a growth of epithelial cells. At the end of a few days the corneal corpuscles begin to proliferate and push aside the elements which occupy the cleft, and thus permanently close the wound. In cartilage, owing to the poor supply of nutriment, the cells appear to take but a feeble part in the process of repair. Incised wounds of joint-cartilage are found many weeks after the injury filled with a clot of fibrin, which eventually is replaced by connective tissue. The cartilage-cells near the wound become polynucleated, and the intercellular substance becomes fibrillated, but this is probably only a retrograde metamorphosis.

New epidermis is formed by proliferation of the epithelial cells. New epithelial cells possess amœboid movements, and may wander a short distance from the margin of the wound. The deep layers of the rete mucosum furnish cells which multiply rapidly, and it is this layer of the skin which is utilized by Reverdin in transplanting small grafts to the granulations. The success of the Thiersch method, which consists in the transplantation of portions of skin several inches in length to the freshly-cut surface of open wounds, is due to this fact. The grafts are cut with the razor and are exceedingly thin, so that only the most superficial portions of the skin are removed.

Regeneration of striped muscular fiber occurs to some extent in slight injuries. The cicatrix following a wound in the muscle is, however, usually composed of connective tissue, and the fragments of the muscle are thus united by a tendinous mass. At first an increase in the size and number of the muscular nuclei

are seen. Some observers have noticed karyokinetic changes in these nuclei. These new cells or sarco blasts assume a spindle shape and are arranged in rows, and at the end of the third week begin to show striations. Each spindle cell elongates, and finally forms a muscular fiber. Regeneration of muscular fiber has been observed in myocarditis, and has also been produced experimentally in animals. Attempts to graft the muscle of a dog into a wound of the biceps following extirpation of a tumor did not succeed. Large loss of substance of muscle, however, may not be followed by much impairment of motion.

Regeneration of nerve-tissue is sufficiently perfect to unite the ends of divided nerves which have been sutured, and to restore even the continuity of nerves which have been resected in their trunks for the cure of pain. Views differ as to the histological changes which occur during the process of repair. Growth appears to be more active from the central end, although it may take place from the peripheral end also. The axis-cylinders become elongated and divide into several fibers, which later are covered by the medullary sheaths. According to another view, the axis-cylinders may be formed by a growth of spindle cells, *neuroblasts*, which takes place from both ends of the divided nerve and unites the two fragments. Around these cylinders medullary substance is deposited later, and new sheaths are thus produced. The completion of the process takes several months. When the ends of the nerve are separated by a distance of over one inch in length, repair can rarely take place spontaneously. The ends of the nerves have then a club-shaped enlargement, due chiefly to a growth of the neurilemma, and many of the fibers become degenerated. Suturing of the ends of a divided nerve, with restoration of function, has been accomplished over a year after the injury.

When a *tendon* is divided the two ends are separated from each other in the tendon-sheath, and a flow of blood fills the intervening space with clot. A growth of cells takes place from the sheath and surrounding tissue, and granulations force their way into the clot, which is absorbed. The new tissue gradually assumes the appearance of a fibrous tissue running parallel with the fibers of the tendon. The tendon does not at first appear to take any part in the process of repair; later it is difficult to distinguish between the old and the new fibers. The new tissue appears to be derived chiefly from the connective tissue.

When a *bone* is broken the new tissue which unites the fragments is usually bone (Fig. 11). A true regeneration of bone, therefore, does take place. The tissue which first forms around and between the ends of the bone is of a temporary character, and is called the *provisional callus*; that formed from the periosteum is called the *external callus*; and that from the medullary tissue, the *internal callus*. The *intermediate callus* lies between the ends of the bone, and is at first, in part, a growth from both of these regions; but it is here that the permanent cicatrix is finally developed from the bone-forming tissue. The size of the callus will depend upon the amount of traumatism and the amount of displacement and of motion during the process of repair. Later the provisional callus is absorbed, and cicatrization is sometimes so perfect that it is difficult to detect the precise seat of an old fracture. In *growing bone* the cells which are most active in the process of development are found in the deeper layers of the periosteum. Here an active cell-growth takes place, and medullary spaces containing the bone-forming cells or *osteoblasts* are developed. A growth of bone also occurs in the deeper layers of the cartilage. Bone-salts are deposited between the cartilage-cells, and the spaces occupied by them are converted into medullary spaces, and the medullary cells, and probably also cartilage-cells,

become converted into osteoblasts. The osteoblasts form new bone by a change of their protoplasm into a finely fibrillated or homogeneous material, which by a deposit of lime-salts is transformed into bony lamellæ. Absorption of bony substance is accomplished by giant cells, now known as *osteoclasts*, which are derived from the protoplasm of the various kinds of cells which come in contact with bony tissues (Tillmans). These cells are said to form carbonic dioxide, which dissolves the lime-salts.

The ossification of the external callus is accomplished by the osteoblasts. These cells are observed developing in the granulation-tissue which has formed between the bone and the periosteum. The osteoblasts develop an osteoid tissue which subsequently, by deposit of lime salts, becomes true bone; or the bone-formation may be preceded by the development of cartilage from these formative cells. In the second week an osteophytic growth is already seen on the surface of the bone, and by the end of the third week the periosteal callus usually consists of firm, spongy bone. A similar formation of bony tissue occurs in the medullary cavity in the development of the internal callus (Fig. 12). The amount of this growth varies greatly in different

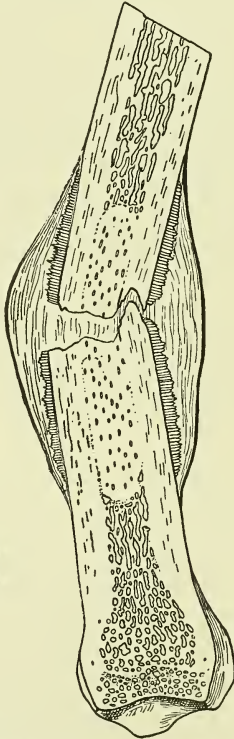
FIG. 11.

FIG. 12.

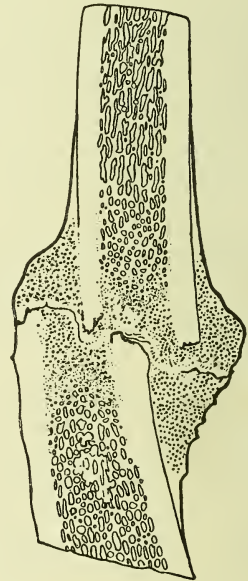
FIG. 13.



Fracture One Week: blood-clot containing fragment of bone (original).



Callus of Fracture (dog) Four Weeks: commencing ossification of external callus (original).



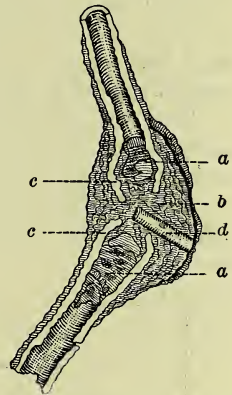
Femur of a Child Fifth Week after Fracture (original).

cases. Formation of cartilage also occurs here near the seat of fracture, but is not so constant or extensive as in the periosteal callus. The provisional callus becomes converted into a permanent cicatrix by a condensation of its tissue. An absorption of its more superficial and deeper portions also takes place—a process which is brought about mainly by the action of the osteo-

clasts. The dense cortical bone at the point of fracture shows at first no change, but subsequently becomes porous and finally unites with the adjoining fragment. It is eventually changed again into dense bone by the action of the osteoblasts. The medullary cavity of the bone, sometimes completely broken in its continuity by an overlapping of the fragments, is finally more or less completely restored (Fig. 13).

The *healing of arteries* after ligature is not unlike that of bone in the sequence of events. We have here also a provisional growth which forms around the ligature and encloses the two ends of the vessel; as in the bone, the size of the "callus," as it may be called, will depend upon the amount of traumatism. In the interior of the vessel a thrombus forms, which in purely aseptic operations is exceedingly small, and it has been maintained by some observers to be absent altogether under these conditions. The proximal thrombus is usually larger than the distal one. The external growth or "callus" is composed of granulation-tissue, and as the walls about the ligature are infiltrated with leucocytes, the ligature loosens its hold upon the vessel, and the two ends retract and separate slightly from one another, but are still held enclosed in the external callus. The ends of the vessel now open slightly, and admit a growth of granulation-tissue which infiltrates the thrombus. Subsequently this granulation-tissue is absorbed, and as it disappears it becomes apparent that a growth has taken place from the walls of the vessel which forms the permanent cicatrix. In the interior a formation of new tissue has taken the place of the thrombus, which now has disappeared. If the thrombus has been a large one, there will be a considerable growth of connective tissue filled with vascular spaces. A new growth of endothelium covers this tissue and lines the new vessels contained in it. In aseptic wounds the amount of connective-tissue growth is small, and we then find, when the process is completed, a crescent-shaped cicatrix at the end of the cul-de-sac formed by the ligatured vessel. The surface of this cicatrix is covered with a new endothelium; below this is a new layer of muscular cells which have developed from the media, and externally is a connective-tissue growth from the adventitia (Warren). The two ends of the vessel are now united by a ligamentous bond. The usual method of ligature is to apply a single thread around the vessel with sufficient force to rupture the internal coats. Unless this is done there is a possibility that the lumen of the vessel may not be obliterated. According to Senn, however, two ligatures can be applied near each other, without sufficient force to rupture the coats, with speedy obliteration of the vessel. Ballance and Edmunds believe that the cicatrix is composed of ordinary scar-tissue formed from the connective-tissue elements in the vessel-walls. They also recommend a double ligature, the material being tendon or peritoneum. Their *stay knot*, recommended for large vessels, is tied as follows: The first hitch of a reef knot should be made on each ligature separately, and the ligatures should be so tightened that the loop lies in contact with the vessel without constricting it. Then, taking the corresponding ends of the two ligatures in the two hands, constrict the vessel so as to occlude it. Then complete the reef knot, treating the two ends in each hand as if they were a single thread. In amputation-stumps the ligatured

FIG. 14.



Carotid Artery of Horse,
Two Months after Liga-
ture: a, thrombus; b,
callus; c, arterial wall;
d, ligature sinus (orig-
inal).

artery does not terminate abruptly in a cul-de-sac at the point of ligature, but is partially obliterated for some distance from the ligature by a growth from the intima and other coats of the vessel. This compensatory endarteritis adapts the vessel to the greatly diminished blood-supply needed for the stump. After ligature in continuity the branches given off above and below the ligature become enlarged, and, anastomosing with one another, establish a collateral circulation.

CHAPTER IV.

THE TRAUMATIC FEVERS.

THE fever which occurs after the infliction of a wound may be *aseptic* or *septic*, according to the conditions which prevail at the time of the trauma or injury.

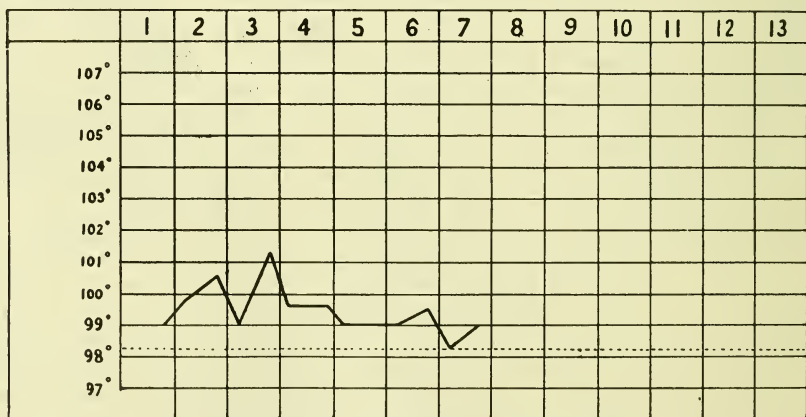
Clinically, surgical fevers may be divided into two main groups, the benign and the malignant types of fever. It is the former group only which is considered in this chapter.

The benign group includes those forms which are described usually as traumatic fever, and includes aseptic fever, septic or "surgical" fever, as it was formerly called, and suppurative fever. To these may be added certain special forms, such as surgical scarlet fever and urethral fever.

The malignant group comprises septicemia, sapremia, and pyemia.¹ Septicemia and sapremia may be regarded as malignant types of surgical fever, and pyemia the malignant type of suppurative fever.

Aseptic fever is characterized by a pyrexia which accompanies wounds healing by first intention. It was formerly supposed that fever was a symp-

FIG. 15.



Temperature Chart of a case of Aseptic Fever (original).

tom necessarily associated with infection of the wound, but after the antiseptic treatment of wounds was perfected it was discovered that many wounds thus treated were accompanied by a considerable rise of temperature, par-

¹ See pp. 59 and 62.

ticularly those in which a large amount of blood-clot existed between the lips of the wound, or in large wounds where, necessarily, more or less bruising of the tissues has occurred (Fig. 15).

It has been shown by experiment that a large number of chemical substances when introduced into the circulation will produce a rise of temperature. Among them is the fluid obtained from defibrinated blood, which contains a substance known as fibrin-ferment. When injected into animals this ferment produces extensive coagulation of blood in the vessels and death. Other substances, as pepsin, and even water, when injected will produce febrile disturbance.

During the healing of a large wound there is necessarily a breaking down of minute portions of tissue and blood-clot, which, with effused serum, are absorbed in greater or lesser quantity. These chemical substances are but slightly altered from their normal condition, but when absorbed appear to have what is known as a pyrogenous or fever-producing action.

The normal temperature of the body is 98.4° F., or 37° C. During this form of constitutional disturbance the temperature may rise to 102° F., and not return to normal for several days. Beyond the pyrexia there are but few symptoms in aseptic fever. The patients thus affected do not suffer from malaise or delirium, and are rarely conscious of feeling ill. They may be able to sit up in bed or to move about the room.

This form of fever is seen during the healing of simple fractures and of wounds in which no drainage has been employed, or in very large wounds which are healing by first intention.

Traumatic, Septic, or Surgical Fever.—Before the introduction of the antiseptic method of treatment all wounds healed with more or less inflammation, even when suppuration did not occur, and this was supposed to be a part of the process of repair. The amount of constitutional disturbance was considerable, and was called surgical or traumatic fever. Examples of this type are seen to-day in wounds that have not been treated antiseptically, particularly those which are due to injuries and have been exposed to septic infection. The presence of bacteria of various kinds in the secretions of such wounds gives rise to a fermentative process during which ptomaines are developed and are absorbed, producing fever. Very few bacteria are found in the blood during this type of fever, and if present they are rapidly eliminated. There is no progressive development of bacteria in the system, as in septicemia.

Surgical fever is not to be confounded with suppurative fever, for, although suppuration may occur in inflammations which produce the former, the temperature falls when suppuration takes place, and the decomposing fragments of tissue, together with the ptomaines they produce, are washed away. This fever is produced by the products of decomposition rather than those of suppuration.

The constitutional symptoms correspond pretty accurately with the condition of the wound and the amount of inflammation. There is a sharp rise of temperature a day or two after the operation or injury; the skin is hot and dry, the pulse rapid, and the tongue coated. The subjective symptoms are also more marked; the patient suffers greatly from heat, thirst, and restlessness, and there may be delirium. The urine is scanty and highly colored. On the evening of the second day the thermometer indicates a temperature of 102° or more in the axilla. The following morning the temperature drops a degree, to rise higher than before in the evening. On the third or fourth day, when suppuration is established, the wound cleans off, granulations spring up, the chemical substances which have caused the pyrexia are

no longer absorbed, and the temperature falls. Surgical fever does not last over a week, by the end of which time the symptoms of fever have entirely disappeared.

The constitutional disturbance in this form of fever usually corresponds pretty accurately with the local condition of the wound. When, therefore, all symptoms are well marked, infection of the wound should be suspected and the dressing should be removed for a thorough examination. The lips of the wound are usually found red, swollen, and tender, and on pressure decomposed blood-clot, and perhaps pus, may ooze at one or two points from between the lips of the wound. The stitches should be removed, the wound opened and disinfected, and a moist dressing in the form of antiseptic fomentations should be applied.

In slight disturbances such a dressing may suffice to carry off all decomposing secretions without removing the stitches, and the wound may heal after all by first intention. Experience only will enable the surgeon to decide whether to interfere or to leave the wound undisturbed.

Suppurative fever, or, as it is sometimes called, **secondary fever**, is a term employed to denote that febrile condition which prevails after suppuration has been established. It occurs only in those cases in which pus is retained, so that some of its constituents are absorbed.

If at the usual period of defervescence of surgical fever we find the temperature remains high, or there is a rise after the usual fall, it is highly probable that an accumulation of pus has taken place between the lips of the wound and is unable to escape. The pyrexia is probably produced by the absorption of a chemical substance which has been formed by the pyogenic organisms. The micrococci are not found to any extent in the blood or tissues, and the fever curve drops as soon as the pus is evacuated. It is evident, therefore, that there is no progressive infection of the system by virus already absorbed, as in pyemia.

When pus is confined in a wound the constitutional disturbance is usually well marked. There is a sharp rise of temperature, accompanied perhaps by a chill. If the pus is evacuated promptly, the suppurative process may be arrested, but occasionally the surrounding tissues become affected and the pus burrows in various directions.

The fever corresponds pretty accurately with the degree of local inflammation. During the acute stage the fever remains high with slight diurnal variations; later, when a state of chronic suppuration has been established and pus is to be found accumulating at the bottom of numerous sinuses, the fever curve assumes a remittent type, falling in the morning to the normal point, to rise again several degrees in the evening. This is the type of the so-called hectic fever (*ἐκτιχός*, a habit), accompanying the chronic suppurations which are so marked a complication of the tubercular process. With the continuance of the fever there are marked emaciation and prostration. The pulse becomes weak and rapid. Diarrhea and night-sweats are often prominent symptoms, and unless the suppuration is checked the patient may succumb to septic poisoning or to exhaustion. In the more chronic form the emaciation is gradual. Enlargements of the lymphatic glands and amyloid degeneration of the internal organs are often found.

The treatment of acute suppuration consists in the establishment of thorough drainage with disinfection of the entire suppurating surface. For this purpose free incisions should be made in order to lay open the pus-cavity and render its walls accessible to the curette. After all the infected material that can be removed is scraped away, the remaining surfaces should be

thoroughly cleansed with peroxide of hydrogen or sulphurous acid (1 : 30) and disinfected with solutions of carbolic acid, corrosive sublimate, or zinc chloride.

When joints are involved the question of resection must be considered. The presence of an amyloid degeneration of the kidneys, as revealed by an examination of the urine, is a contraindication to resection, and in these cases amputation may offer a better chance of saving life.

Free stimulation and a nutritious diet are indispensable. In many cases placing the patient in the open air for several hours daily may bring about a decided improvement, even in serious cases. When, however, those processes are associated with tuberculosis the prognosis is most unfavorable.

Surgical Scarlet Fever.—A scarlet rash may occur after surgical operations, and the eruption may be followed by desquamation. In many of these cases there has been an infection of the system through the wound with the virus of scarlet fever. Such infections are more likely to occur if the wound involves a mucous membrane, as in cases of lithotomy. The appearance of the symptoms of surgical scarlet fever are, according to Paget, quite “disorderly,” the period of incubation, for instance, being much shorter than usual. Scarlet rashes may occur also as the result of vaso-motor disturbances, or from the absorption of a chemical poison from the wound, or from bacterial invasion, as in pyemia and septicemia.

Urethral fever is a term given to the chill and pyrexia which often follow the introduction of a catheter or sound into the bladder. It has been cited as an example of the purely nervous origin of fever.

Many of these cases are probably due to the infection of a wound of the mucous membrane caused by the instrument, but some cases are not to be accounted for in this way, but are to be explained only by reflex nervous action.

TRAUMATIC DELIRIUM.

This term is used to denote those forms of delirium which occur as the result of injury, and are not due to alcoholism.

The anatomical seat of delirium is in the cortical gray matter of the brain. The delirium is due either to functional disturbance or anemia of that region or to inflammations of the cortex and meninges—more particularly of the middle and posterior lobes (Hunt). The causes of delirium are as numerous almost as the injuries which give rise to constitutional disturbance, but there are certain lesions which seem more prone to this form of functional disturbance than others. In some cases of shock there is considerable mental exaltation and excitement which are quite characteristic, the condition being known as “prostration with excitement.” There is usually no marked delirium, but at times a temporary mental aberration of a well-defined character. It may precede and accompany cerebral lesions, such as hemorrhage from trauma, or thrombosis and embolism.

Delirium is often noticed in children after capital operations, being out of proportion to the amount of fever which exists. In traumatic fever of a severe type, as we have seen, delirium may be present. Among other surgical lesions, severe burns and scalds and facial erysipelas may be mentioned as particularly liable to be accompanied by delirium. In some individuals pain alone is often sufficient to produce a temporary mental aberration, which disappears immediately upon the subsidence of the pain. This form of delirium is allied to the so-called *delirium nervosum* of the German writers—a condition of nervous disturbance which comes on after injuries in hysterical subjects. It may occur in the stage of convalescence following erysipelas and other inflam-

matory diseases in nervous patients. It is characterized by considerable mental depression. Transitory psychological disturbances may also follow surgical operations, and there may be developed at times not only melancholia, but a suicidal mania. A nervous delirium without fever is occasionally noticed after operations upon portions of the body supplied with unusually sensitive nerves. The operation for phimosis, with an unusual amount of irritation of the glans penis, is an example. Severe nervous disturbance and delirium following operations or injuries, without a corresponding amount of inflammation or fever, should cause the surgeon to inquire as to the possibility of poisoning by iodoform or carbolic acid—conditions readily shown by an examination of the urine.

The treatment of this form of delirium consists in the removal of all local sources of irritation, in the application of ice to the head in some cases, and in the use of the bromides and hypnotics. If due to cerebral anemia from loss of blood, suitable stimulation is indicated. Opium is usually not well borne, and should be reserved for those violent cases which cannot be controlled in any other way.

DELIRIUM TREMENS.

This disease is a form of mental disturbance characterized by delirium, and accompanied by a peculiar tremor of the muscles, occurring in individuals habitually intemperate in the use of alcoholic stimulants. It follows either a debauch or some injury which suddenly confines such a patient to bed; hence its consideration here. It is said to be much less common in countries where wine and beer are the national beverages than in those in which spirituous liquor is consumed. The habitual use of various drugs is said to produce it, as opium, tobacco, and cannabis indica, and even tea and coffee. The term *mania-a-potu* is used to denote an acute type of delirium following a debauch, in which the patient may become maniacal.

Delirium tremens was formerly supposed to be due to an inflammation of the brain. Usually, however, the post-mortem appearances indicate no sign of active inflammation beyond some thickening of the meninges. According to Hunt, there is a condition so characteristic that it has been called "wet brain," consisting of a passive congestion with serous exudation in and under the pia mater, filling the ventricles and following the convolutions. Chronic gastric catarrh is also found to exist, and atheromatous degeneration of the arteries, fatty liver, and Bright's disease.

The symptoms of delirium set in gradually. The patient, removed from his ordinary surroundings, complains of feeling uncomfortable; he is restless and tremulous; there is much depression of spirits, and his sleep is disturbed with nightmares; he talks in his sleep, and may wander about during the night, but the next morning asserts that he has slept well. When it follows an injury, the onset of the disease is usually sudden. With the full development of the disease there is complete insomnia, with a muttering delirium frequently broken by loud cries, and a peculiar tremor of all the muscles. The patient is constantly employed pulling the bed-clothes about, tearing off dressings and splints, and endeavoring to get out of bed. He appears to be more or less insensible to pain, and may walk upon a broken leg without showing any signs of suffering. He is the victim of all manner of delusions, usually of a horrible nature. The hallucinations take the form of hideous animals and insects; occasionally they are obscene in character. The patient may be momentarily recalled to himself sufficiently to give an intelligent answer, but relapses immediately into his previous condition. There is little fever, although occasionally there may be a marked rise of temperature. The

pulse is weak and quick, and there is rapid loss of strength, due to the small amount of nourishment taken during the debauch and the later inability to retain food.

In favorable cases, after two or three days of insomnia sleep comes suddenly, and on awakening the delirium is found to have disappeared. In severe or fatal forms the prostration increases rapidly and is a marked feature, the pulse failing greatly in strength. The patient may die suddenly from heart failure. Pneumonia, a complication unusually frequent in alcoholic subjects, may supervene, and bring about a fatal issue. The prognosis of the disease is, however, usually favorable. Among the most reliable symptoms which give a clue to the patient's condition are the pulse and temperature. The weak and rapid pulse is a measure of the prostration, and the rise of temperature is a warning of complications such as pneumonia or septic infection of the wound.

The prophylactic **treatment** consists in the employment of alcoholic stimulants in moderate quantities, of capsicum and digitalis, and of nourishing food. The last is only secondary in importance to sleep. By these means the nervous system is steadied and the strength of the patient maintained. Any indication of nervousness or insomnia should be met with a free use of the bromides. An attack may in this way be warded off. During the attack mild stimulation with liquor or beer is usually advisable, although the use of stimulants must be determined by the circumstances of each case. The drugs which are most frequently used at the present time are chloral hydrate and the bromides. It is probable that sulphonal in sufficient doses to cause sleep has rather too depressing an influence upon the heart's action. The question of the use of opium in this disease has been much discussed. In mild cases it is not necessary, but it may be of much value in quieting restlessness when it is of great importance that splints or dressings should not be disturbed, or when the delirium is of so acute a type that all other remedies fail to control the patient.

CHAPTER V.

SUPPURATION AND ABSCESS.

SECTION I.—SUPPURATION.

SUPPURATION is due to the action of the pyogenic cocci upon the tissues, and is the usual termination of infective inflammation. It is the process by means of which the exudate and the tissues involved become liquefied and converted into pus. The organisms most frequently found in pus are the staphylococcus pyogenes aureus and albus. They have a tendency to accumulate in clusters, and when growing in the tissues produce circumscribed forms of suppuration. The streptococcus, which is sometimes present, on the other hand, shows less tendency to cause local suppuration, but spreads rapidly through the tissues by the lymphatics, and eventually gives rise to a diffused form of suppuration. When grown on beef gelatin the staphylococcus causes a liquefaction of the culture medium in virtue of its peptonizing action, which is due to the presence of a soluble peptonizing ferment, and it is in consequence of this action that the fibrinous exudate and the inflamed tissues become converted into pus.

That the pyogenic cocci are the cause of suppuration has been abundantly

shown by microscopical investigation and experiment. They are found in the pus of all acute abscesses, and sometimes in cold abscesses. The failure to find them in the latter class of abscess has been explained in various ways. By some these abscesses are supposed to be caused by the bacillus of tuberculosis alone, but the most probable explanation is the dying out of the organisms and the deposition of their remains as a sediment. Experiments on animals show that these organisms when injected in sufficient quantity under the skin will produce suppuration. When absorption takes place rapidly, however, a larger quantity can be injected without producing suppuration. In man inoculation through abrasions or wounds, and even through the uninjured skin, will cause suppuration. Garré produced furuncles of the forearm by rubbing in a culture of the aureus. The question of suppuration without the agency of bacteria has been carefully studied recently. Experiments on animals with the injection of calomel, mercury, turpentine, and croton oil show that certain drugs can produce in certain animals pus, or, as it would be better called, "puruloid material," containing no bacteria. Non-bacterial pus can also be produced by introducing cultures of cocci which have been sterilized by heat. In this case the organisms have been removed, but their chemical products still remain, and are undoubtedly important factors in the production of inflammation and suppuration. Practically, however, the surgeon never has to deal with non-bacterial suppuration.

Among the predisposing causes of suppuration may be mentioned diminished vitality of the tissues. The healthy body is intolerant of bacteria, and will resist the invasion of a mass of organisms which an inflamed or diseased part may be unable to withstand. The milder types of inflammation seem particularly well adapted to encourage bacterial growth. Some of the severest types of suppuration, such as acute osteo-myelitis, follow often slight blows or injuries. The delicate reticulum of blood-vessels found in the medullary cavities of bones furnishes a convenient lodging-place for swarms of bacteria, owing to the slowness of the blood-current and the tortuous course of the blood-channels. When the circulation has been impaired or arrested by an extravasation of blood or a congestion of the part, the conditions are favorable for an intravascular infection if organisms happen to be circulating in the blood at the time. As we have seen, micro-organisms may from time to time be found in the circulating blood, particularly in individuals of feeble constitutions. The anatomical nature of the part will therefore favor suppuration in certain localities. A most familiar example is the lymphatic gland tissue. There the organisms which have invaded the tissues through a wound, and have found their way into the lymphatic vessels, are arrested, and a glandular abscess results. The condition of the blood is also a predisposing cause, as the tendency to carbuncular inflammation in diabetes shows.

The material which forms as the result of suppurative inflammation is pus.

Pus is a yellowish-white fluid of the consistency of milk or cream, of an alkaline reaction, and commonly nearly odorless. It has a specific gravity of about 1030, and when allowed to stand it separates into a clear fluid known as pus serum, and a sediment which averages from 10 per cent. to 20 per cent. of the whole amount.

The *liquor puris*, or pus serum, is a pale greenish-yellow fluid which does not coagulate spontaneously, and contains an albuminous substance known as peptone. The salts which it contains are present in about the same proportion as in the blood.

The sediment consists of pus-corpuscles, the pyogenic cocci and the other

forms of micro-organisms that may be present, and fragments of broken-down tissue.

Most of the *pus-corpuscles* are the altered leucocytes which have escaped from the blood-vessels with the exudation; others are derived from the proliferated fixed connective-tissue cells. When first taken from a fresh abscess many of them are found to possess amœboid movements. They are a little larger than the white blood-corpuscles. Their protoplasm is somewhat granular, and when acetic acid is added to them they are found to contain several nuclei. This polynuclear condition was supposed to be evidence of an ability of the pus-corpuscles to proliferate, but it is now recognized as a sign of degeneration. They also occasionally contain drops of fat; others are full of large granules, which, when they break up, liberate a granular detritus which may be seen suspended in the fluid.

The color of pus is occasionally blue. This is due to the presence of the bacillus pyocyaneus, ordinarily considered a harmless organism, but the presence of which indicates slowness of repair. Orange-colored pus is caused by the presence of hematin crystals, and is found in some forms of inflammation. It is probably due to the fact that many red corpuscles in the exudation have been broken up by the septic process.

The peculiar foul odor of pus which comes from the neighborhood of the vagina or rectum is due to the presence of the bacillus pyogenes fœtidus. The thick creamy, odorless pus which flows from an acute abscess was formerly known as healthy or laudable pus. It contains comparatively few bacteria. Pus may occasionally undergo decomposition; in this case the micro-organisms of putrefaction also are found in it, and the pus-corpuscles are broken down and much diminished in number. This is known as *ichorous* pus, and when mixed with blood which is seen flowing from a rapidly-spreading abscess is called *sanious* pus. These unhealthy forms of pus are very acrid and give an acid reaction.

A microscopical examination of the connective tissue in suppurative inflammation shows that in the early stages of the process the stellate cells of the tissue lose their prolongations, become rounded, and undergo karyokinesis, and multiply in this way. In the mean time the intercellular substance undergoes a softening process, is transformed into a homogeneous substance, and the proliferated connective-tissue cells are in a state of polynuclear degeneration. This stage is the one immediately preceding that of pus formation. Many of these degenerated cells are therefore of connective-tissue origin, and under some circumstances they may even outnumber the leucocytes. When the polynuclear stage has been reached, it is impossible to tell the origin of these cells.

Suppuration is always to be regarded, as it has been aptly described as a "battle of cells," the bacteria exerting, in all probability, a chemiotactic attraction which for bacteria is irresistible.

When acute suppuration takes place the symptoms of inflammation all become more marked. There is great increase in redness and swelling, and the part is exceedingly hot and is the seat of a throbbing pain. The formation of pus is often ushered in by a chill or rigor, and a change in the conditions of the part will indicate the locality of the pus. The skin at this spot becomes adherent to the parts beneath, and later presents to the touch the sense of fluctuation. A deeper color is also present at this point, and in the centre of the focus a whiter zone indicates the stage immediately preceding the breaking down of the abscess and the discharge of pus.

The diffused forms of suppuration in connective tissue are called

phlegmonous inflammations. This variety is usually seen after compound fracture when septic infection has occurred, and may involve the greater portion of the limb, as the forearm, the arm, or the leg. An acute swelling, with œdema of the connective tissues, ushers in the process, and areas of bogginess or fluctuation will make themselves manifest later. The constitutional disturbance will usually be great. A sharp rise of temperature, accompanied perhaps with a chill, will mark the beginning of the suppuration, and the pyrexia will remain until free incisions and thorough drainage have arrested the progress of the pus. The route which pus takes under these circumstances depends upon the anatomical structure of the part, upon gravity, and also upon the nature of the organisms. In many cases pus will continue to burrow until the integuments have been freely divided and the margins of the suppurating area have been fully exposed. The improvement following such free incisions is due to the fact that the bacteria growing in the wall of the abscess are thus freely exposed to the air, a condition less favorable for their growth, and are more readily reached by antiseptic agents. Small incisions are of little use in the more rapidly-spreading forms of cellulitis, and incisions from six to twelve inches in length are sometimes required to arrest the progress of the disease. If the treatment adopted fail to arrest suppuration, it may pass into a chronic stage; the pus will then burrow slowly and make its appearance at many different spots. There will also be considerable constitutional disturbance, marked by a progressive emaciation and gradual exhaustion of the patient. The febrile disturbance will be of the remittent type known as hectic fever.

Purulent infiltration of a limb is a still more malignant form of inflammation. Originating in a suppuration perhaps at first trivial, it will spread rapidly, and its involvement of the lymphatics of the limb will be plainly indicated by red lines extending up to the axilla or the groin. The protective influence of the lymphatic glands will be shown by their filtration from the lymph-stream of the cocci and their ptomaines. This leads to the formation of an abscess just above the elbow or in the axilla or groin, which temporarily arrests further progress of the suppuration. More rarely the entire limb will be involved in an acute inflammatory swelling with little tendency to suppuration. In this case the whole part is apt to become gangrenous. Free incisions are followed by the escape of a sero-purulent fluid. There is profound constitutional disturbance with perhaps acute septicemia. Probably in these cases there is a mixed infection, and bacilli of putrefaction are mingled with the micrococci.

When infection of a wound takes place the slight swelling which ordinarily accompanies the healing process is much increased at some portion of the wound, and is accompanied by reddening and induration. This will usually occur around one of the stitches which has been the source of infection, or pus may collect in some part of the wound where the surfaces were not accurately brought in apposition and where the wound fluids have accumulated from imperfect drainage. The rise of temperature will give speedy warning of the approach of suppuration in such cases.

The general plan of **treatment** to be adopted in cases of spreading suppuration is the employment of free incisions which expose the extreme limits of the suppurating area. This operation should be accompanied by a thorough curetting of the surface of the pus-cavity to remove the bacteria from the surrounding tissues and by thorough disinfection with appropriate antiseptic drugs. In the case of an extremity this can best be accomplished by immersion of the limb in an antiseptic bath. The agent used should be largely diluted (sublimite 1 to 10,000, or carbolic acid 1 to 500) to prevent poisoning by the drug. Following the bath antiseptic fomentations may be applied.

For this purpose some of the milder drugs containing carbolic acid, as sulpho-naphthol, may be used. When other methods fail, irrigation is often successful. Sterilized water may be used for this purpose or extremely weak solutions of disinfectants. If a dry dressing is preferred, iodoform or aristol or boric acid may be dusted freely upon the part, and the wound may then be packed with an antiseptic gauze. The use of stimulants and careful feeding should be the chief feature of the general treatment of the case.

SECTION II.—ABSCESS.

AN ABSCESS is a circumscribed collection of pus, and is caused usually by the presence of the staphylococci in the tissues. When these organisms invade a part, we find even at the end of twenty-four hours an enormous number of leucocytes in the exudation which takes place. The connective-tissue fibers are swollen and the lymph-spaces are distended and filled with cells. As we have already seen, the fixed cells of the tissue undergo changes of an active nature, and form nucleated cells which cannot be distinguished from the leucocytes: they are, however, usually much less numerous than the latter. The small vessels are dilated and distended with blood, and in many cases with leucocytes. The cocci in the mean time increase in number and tend to group in masses. As they exert a peptonizing action upon the intercellular substance and the fibrin of the exudation, liquefaction takes place in the center of the inflamed tissue, and an abscess is formed. The walls of the pus-cavity are formed by a zone of granulation-tissue, the cells and intercellular substance of which have not been broken down by the action of the bacteria, and remain to form a protecting layer between the infected area and the surrounding healthy tissues. This is the mode of development of an abscess in some of the looser tissues like connective tissue. In the denser structures and in the internal organs when a plug of micrococci becomes arrested at some point in the circulation, as, for instance, in a glomerulus of the kidney or in a lymphatic gland or in the cutis vera, we find that the tissue immediately surrounding it undergoes a chemical change due to the action of the ptomaines upon its cells, the result of which is that coagulation-necrosis of the tissue takes place. This ring of dead tissue is readily seen in sections taken for microscopic purposes, as the necrosed area does not take any of the staining fluids which act upon the surrounding tissues. Outside of this area a ring of granulation-tissue forms. Eventually the necrosed area is invaded both by the bacteria and the leucocytes, and becomes liquefied by the action of the cocci. An abscess of this type, when examined microscopically, will show a mass or plug of bacteria in the center, around which is a layer of pus and shreds of tissue enclosed in a zone of granulation-tissue, the mis-called pyogenic membrane of the older pathologists, who thought that the wall of an abscess was a sort of secreting surface from which pus was formed.

The **symptoms** of an acute abscess are usually well marked. The large amount of local swelling, with a varying amount of pain according to the density of the tissues which lie between the cavity of the abscess and the surface, is accompanied frequently by a chill or a gradual rise of temperature as pus begins to form. As the abscess forms a progressive softening of the integuments takes place until the pus reaches the surface. Considerable resistance will be offered by certain tissues, as fasciæ, a joint capsule, or bone, and the pus may take a devious path before the abscess begins to point. Fluctuation will now be distinctly felt, and redness with oedema of the skin and subcutaneous tissue will indicate the near approach of pus. The skin becomes

stretched and thin and its vessels compressed, and over a certain area the blood will not circulate; death of this area occurs, and the abscess then easily breaks through it.

It is not usually difficult to **diagnosicate** the presence of an acute abscess. Acute forms of inflammation may occur, however, in which the sensation of fluctuation is apparently well marked when an incision fails to reveal the presence of pus. No harm is done, the inflammation may be relieved by such an operation, and the impending abscess prevented.

Deeply seated abscesses under a dense fascia, as in the neck, may be overlooked, as no fluctuation can be felt. The local oedema and brawny feel, with other signs of suppuration, are always a sufficient warrant for a deep but careful exploratory incision at an early date to prevent wide and dangerous burrowing of the pus under the fascia. An aneurysm may, however, be mistaken for abscess, particularly when its presence is obscured by the symptoms of inflammation, and the use of the knife in such a case would be a grave error. An aneurysm will declare itself by its less acute history, by the thrill, bruit, and expansile pulsation, and can exist only in connection with a large vessel. Some forms of rapidly-growing malignant tumors may also simulate suppurative processes. In all such cases the use of the aspirator or of the hypodermatic needle is of great value. The heat of the part, the sense of fluctuation, the local oedema, and the rise of temperature, as shown by the thermometer, are all important diagnostic symptoms, and will usually be sufficient to establish the presence of an abscess.

When an acute abscess breaks the pus which is discharged is of a thick cream-like consistency, and is frequently mingled with soft sloughs of connective tissue or fasciæ, or fragments of lymphatic glands which have undergone a necrosis due either to the great tension of the part or to the formation of destructive chemical substances by the pyogenic cocci.

The **treatment** of acute abscess consists in incision as soon as it can be definitely ascertained that pus has formed, and sometimes even earlier. Nothing is to be gained by delay, and extensive injury may be inflicted upon the surrounding tissues if the abscess is not opened early. In some regions the dangers of delay are very great. An abscess in the neighborhood of the appendix vermiformis may produce a fatal peritonitis if allowed to remain unopened. Deep-seated abscesses of the neck may burrow widely, and may seriously interfere with respiration by pressure upon the trachea. An abscess near the rectum should be opened as soon as induration is discovered, in order to prevent a fistula. If no pus has formed the incision may prevent it.

The incision, as a rule, should be a free one, and so made as to favor drainage and to leave the least conspicuous scar. The finger should then be introduced to determine the size and situation of the various pockets. In case of abscesses near large vessels or other important structures Hilton's method may be used to advantage. This consists in making an incision through the skin and deep fascia by the knife. The seat of the pus can be ascertained by pushing in a pair of closed hemostatic forceps or blunt scissors or a sinus dilator, and the opening so made can be easily enlarged by drawing them out open. If necessary, to facilitate the escape of the pus by gravity, a counter-opening can often be made by pushing the hemostatic forceps entirely through the tissues to the opposite skin, and cutting between its partly opened blades. The cavity of the abscess should be thoroughly emptied, curetted, and syringed out with antiseptic solutions. These may consist of corrosive sublimate 1:5000 or carbolic acid 1:100, or if a milder antiseptic fluid is needed phenyl (sulpho-naphthol) 1:250. When the pus and sloughs have been thoroughly removed in this

way, a drainage-tube of a sufficient size should be inserted, and retained either by a safety pin inserted through its extremity or by stitching it to the skin to avoid its falling out of the abscess, or, still worse, of being lost in its cavity. An antiseptic poultice (made of aseptic cotton and cheese-cloth and wrung out of a weak antiseptic solution) may be applied, or a dry absorbent dressing may be used. In freely-discharging abscesses the dressing should be changed at the end of twelve hours or less, and the cavity washed out again. The fountain syringe fitted with a tube ending in a conical glass point is well adapted for this purpose. It gives a continuous stream, and causes but little pain to the patient in its application. In a few days the inner surface of the abscess-wall "cleans off" and healthy granulations make their appearance. The tube can be shortened daily as the cavity shrinks, but the time of its removal will depend entirely upon the length and ramifications of the cavity.

Cold abscess is caused in the great majority of cases by tubercular infection, although occasionally it may be of syphilitic origin. In the ordinary tubercular cold abscess we find a peculiar membranous wall formerly called the "pyogenic membrane" (the "pyophylactic membrane" of Park), which is readily scraped off and is infiltrated with tubercles. In the syphilitic abscess no such condition exists. This membrane, as also the pus of cold abscess, is more fully described in the chapter on Tuberculosis. The organisms found in the contents of the abscesses before they are opened are the bacilli of tuberculosis. Sometimes before, and always after they have opened spontaneously or have been opened without due antiseptic precautions, there is added the infection with pyogenic cocci, or the bacteria of putrefaction. This is an example of what is called *mixed infection*. Clinically, we find few of the symptoms of acute abscess. There is in most cases no redness of the part until the abscess is about to break. Pain and heat are usually wanting. The swelling is frequently quite large and fluctuation is distinct. Such abscesses may exist for months before they burst. During their formation the constitutional disturbance is usually slight. There may be, however, considerable emaciation due to the progress of the tuberculosis. The temperature is usually slightly raised, and in cases of doubtful diagnosis the thermometer will give valuable information. One of the most common seats of cold abscess is the vicinity of the spinal column, and such abscesses are due to tubercular disease of the vertebræ (Pott's disease). The pus burrowing along the psoas muscle (psoas abscess) points above or below Poupart's ligament or on the thigh external to the vessels, or it may point in the lumbar region near the margin of the quadratus lumborum muscle (lumbar abscess).

Treatment.—These abscesses should be opened with every antiseptic precaution, otherwise true suppuration with hectic fever will follow from the mixed infection which inevitably occurs. They must be thoroughly scraped out and the wound stuffed with iodoform gauze. Such treatment is best adapted to those abscesses which have few ramifications, and the walls of which are everywhere accessible to the curette. Treves treats psoas abscess by an opening in the loin which passes external to the latissimus dorsi and erector spinæ muscles and through the quadratus lumborum and psoas muscles. The diseased vertebra is first explored, and fragments of bone are removed, and the abscess-wall is repeatedly scraped and wiped out, and also washed out with a douche of corrosive sublimate, 1:5000, at 100° F. The wound is then closed and dressed with an iodoform dressing retained by a bandage. The patient should be kept at rest in the recumbent position for many months. If the abscess-cavity refills, the operation should be repeated.

In many cases of cold abscess it is well to evacuate the contents with the

aspirator and to inject some preparation of iodoform. A large canula is sometimes necessary, owing to the thick plugs of cheesy matter which obstruct the flow of pus. The cavity is now washed out with a 3 per cent. solution of boric acid. Among the preparations of iodoform recommended is a 5 per cent. ethereal solution, but not more than three ounces should be injected for fear of iodoform-poisoning. It causes considerable pain. A 10 per cent. emulsion of iodoform in olive oil can be introduced safely. The following emulsion is also sometimes used, and is considered safe so far as poisoning is concerned: Iodoform 10 parts; glycerin 20; mucilag. gum. Acac. 5; carbolic acid 1; and water 100 parts. From one to three ounces should be injected, and the abscess-cavity should be carefully manipulated so as to introduce the drug into all the pouches. Two or three such injections are made at intervals of three or four weeks. A cure may not be obtained for several months. Equal parts of iodoform and olive oil may be injected freely into tubercular sinuses which have resulted from the bursting of such abscesses. If this treatment fails, recourse may be had to incision, as above described.

The general treatment consists of good food, cod-liver oil and other tonics, and a careful selection of climate. Mechanical contrivances may be needed for the support of joints or bones.

Abscesses of different regions of the body possess characteristic peculiarities. The most common form of abscess in the integuments is the **furuncle** or **boil**. This is caused by a growth of the cocci from the deeper layers of the epidermis downward along the sheaths of the hair-follicles, and a final accumulation near the root of a hair. If the cocci are arrested in their growth at the mouth of the follicle, a pustule is formed, but in many cases the development continues downward and a true furuncle is developed. The boil in its early stages appears as a pustule. The amount of coagulation-necrosis is considerable, and the result is a "core" which is discharged when the abscess breaks. A crucial incision will promptly arrest the growth of a boil in its early stages, or an application of the liquefied crystals of carbolic acid may be used if it is desired to avoid a scar. A **carbuncle** is a suppurative and necrosis of the subcutaneous tissue, and is situated most frequently under the thick skin of the back of the neck. Like the boil, it is at first superficial, but rapidly spreads to the deeper parts. It has erroneously been called a collection of boils, owing to the fact that numerous points of pus appear on the surface, and when opened it presents a honeycombed appearance. This peculiarity of the carbuncle is due to the anatomical structure of the skin and subcutaneous tissues of this part of the body. The pus forms in the dense fibrous reticulum which underlies the thick cutis, and makes its way to the surface through the columnæ adiposæ, in which the fine lanugo hairs are situated, causing disintegration of the parts and sloughing of the tissues and the formation of a central crater (Warren). The carbuncle should be freely incised and all the sloughs removed by the sharp spoon or scissors, and the part disinfected as thoroughly as possible. Complete excision of the carbuncle with thorough disinfection of the parts will often lead to an arrest of the process and a speedy convalescence. Abscess of the *lymphatic glands* may form in the groins, as the result of suppuration complicating venereal disease; in the neck, following inflammation of an adjacent mucous membrane; in the axilla, as the result of suppuration in the fingers or hand; or in the saphenous glands, from suppuration in the toes or foot. **Felons** and **palmar abscesses** are often supposed to be caused by direct local trauma, but are more frequently due to indirect infection by pyogenic cocci which probably follows an injury of some kind. The precise seat of the suppuration will vary

according to the situation of the infection. Nowhere is an early incision of more importance, as the usefulness of the finger or hand is at stake.

When abscesses form in and around the internal organs they usually are designated by special names frequently derived from the organ with which they are associated, as the *perinephritic* and the *perityphlitic* abscesses and abscess of the *space of Retzius*. They should be opened as early as possible and treated as above. Abscesses of the *liver* are rare in America, but are occasionally met with. They are due to infection originating in the digestive tract, and are associated with disturbances of that region more frequently seen in tropical climates. They may sometimes be cured by repeated aspiration, but frequently they must be reached by laparotomy followed by drainage and suturing the edges of the opening of the abscess to the abdominal incision. Pus in the thorax is most frequently found in the pleural cavity, constituting **empyema**. Such an abscess can rarely be cured by aspiration, but should be promptly opened and drained. A cure may be retarded by the mechanical difficulty of bringing the abscess walls together, owing to the contraction of the lung and the rigidity of the chest wall. In these cases resection of several ribs is necessary to allow the thorax wall to come in contact with the lung. (Estlander's operation). Tuberculosis is often a complication of this variety of abscess. Abscesses occur also, but much more rarely, in the lung itself. These can be opened and drained by an incision through or between the ribs. The operation is much simplified if adhesion of the lung to the thorax wall has already taken place.

CHAPTER VI.

ULCERATION AND FISTULA.

SECTION I.—ULCERATION.

AN ULCER is a granulating surface, usually of the skin or mucous membrane. There is also a tendency to necrosis or death of the granulations which are formed by the tissues in an effort at repair. If the retrograde changes equal the reparative, the ulcer will remain stationary, but if the former exceed the latter, the ulcer will constantly increase in size.

The **causes** of ulceration are of widely different origin. Some develop during the course of certain infectious diseases, particularly those of a chronic type, as syphilis, tuberculosis, leprosy, and glanders. Another kind of ulcer depends upon widespread disturbances in nutrition. These are known as dyscrasic or constitutional ulcers. To this class belong the scorbutic ulcers, which appear to form as a result of disease of the blood-vessels brought about by the absence of a sufficient variety of nutriment; also the cachectic ulcers, due to exhaustion of the system from starvation, exposure, or disease.

Ulceration may also be favored by certain local conditions. A passive hyperemia due to retardation in the venous circulation may be the cause of the varicose ulcer. *Decubitus*, or *bed-sore*, is due to a feeble circulation, which is easily arrested by continuous pressure from lying in bed, causing death of the part. *Neuro-paralytic ulcers* are caused by diminished innervation. The so-called trophic disturbance belongs in this class. A striking example of this variety is the "mal perforant," or *perforating ulcer of the foot*. We

may also have ulceration as the result of the breaking down of *malignant growths*, as sarcoma and carcinoma, particularly in the epithelial forms of the disease.

Finally, ulcerations occur which are the result of certain *mechanical difficulties* obstructing the healing process. Extensive loss of substance, burns of the skin, or avulsion of the scalp may result in the existence of a permanent granulating surface constantly contracting or enlarging, but never fully healing. Sloughing of the flaps of an amputation-stump may be followed by an adhesion of the integuments to the ends of the bones, which protrude slightly and are covered with granulations. Wounds may be prevented from healing by mechanical irritation, such as chafing or rubbing or the application of irritating ointments or acids.

A section taken from an ulcer and examined microscopically shows generally a thickening of the tissues around the ulcer due to a hypertrophy of the papillæ and an accumulation of the epidermic cells, which sometimes form an overhanging mass, giving the appearance of "callous edges." In the deep layers of the rete mucosum and in the papillary layer of the true skin deposits of blood pigment are often seen. The surface of the ulcer is covered with a layer of granulation-tissue. This tissue may resemble the type seen in healthy granulations, being composed of round cells closely packed together and supplied with a rich capillary network of blood-vessels, or we may find a condition of coagulation-necrosis due to breaking down of portions of the granulations. In old ulcers the cell-growth is much less abundant, and a gelatinous intercellular substance is seen in which clusters of cells are scattered here and there. The granulation layer is quite superficial, and beneath it we see either the nearly normal tissue or a mass of fibrous cicatricial tissue.

Ulcers are classified not only on the basis of their mode of origin, but also according to certain peculiarities which are characteristic. Thus an ulcer may be healthy, fungous, erethistic, callous or atonic, phagedenic, etc.

A *healthy ulcer* is one in which the granulations are small and florid and the edges show a bluish border of cicatrization. If it be small, it may be allowed to scab and cicatrize under the crust. If larger, carbolated oxide-of-zinc ointment, with or without calomel (3j @ 3j), with suitable protection by a bandage, and rest, is all that is needed as a rule. Simple avoidance of irritation by means of a bit of "protective" or gutta-percha tissue under an antiseptic dressing is often better than ointments. If slow in healing, stimulation by the occasional light application of nitrate of silver or a solution of chloral (gr. x @ 3j) or potassio-tartrate of iron (gr. v @ 3j) will be useful. Skin-grafting is required in large ulcers, and is now done early in many cases of large loss of tissue which would result in an ulcer at a later period. For the details of its application see the chapter on Plastic Surgery.

The fungous or exuberant ulcer may be caused by an obstruction of the venous circulation due to cicatricial contraction and induration, and may be seen after burns and other injuries followed by undue contraction of the surrounding tissues. The granulations will protrude above the edges of the wound, and are congested and bleed readily. The application of the solid nitrate of silver, a solution of sulphate of copper (gr. i-x @ 3j), or shaving off the exuberant granulations with a bistoury, followed by compression by Martin's rubber bandage or strapping or skin-grafting, will favor the healing of such ulcers. When the fungous granulations are pale and œdematous, they may be due to tubercular disease, and in this case a thorough curetting of the surface should precede the application of caustic or actual cautery.

The erethistic, irritable, or painful ulcer is a name applied to ulcers which

are extremely sensitive. The cause of this sensitiveness is not always clear. They are found in regions liberally supplied with sensitive nerve-fibers, as the anus or matrix of the nail, and are then doubtless due to an exposure of the terminal nerve-branches in the wound. They are found frequently in the lower extremities about the ankle or over the surface of carious bone, as the tibia. *Fissure of the anus* is a good instance of this kind of ulcer, which by inducing constipation and other digestive disturbances often seriously undermines the general health. It is easily overlooked unless carefully sought for in the folds of the anal mucous membrane. It is best treated by forcible dilatation of the sphincter muscle. *Ingrowing nail* or ulceration of the matrix of the nail is due to irritation from a sharp corner of the nail, which should be removed. The local treatment consists of drying and soothing powders, such as iodoform, or, better, the removal of the sensitive granulations with the curette or knife under cocaine anesthesia, and protection of the raw surface by daily packing a very small bit of absorbent cotton under the edge of the so-called "ingrowing" nail. It is really "overgrowing granulation" rather than "ingrowing nail."

The callous ulcer is sometimes called indolent or atonic, and is due to a diminution to the minimum of the reparative process. The thickened edges are caused by the ineffectual attempts of the surrounding skin to form cicatricial tissue and epidermis. It is found in laboring and ill-nourished people, and is often due to the presence of varicose veins (varicose ulcers) or to eczema of the skin. Occasionally we find, as the result of long-standing disease and neglect in old people, a general hypertrophy of the affected leg, simulating elephantiasis. The treatment of such ulcers consists in rest in bed, elevation of the limb, and the employment of antiseptic or emollient dressings, and later perhaps skin-grafting. These ulcers are likely to recur unless support is given to the part by an elastic stocking or a bandage of flannel cut bias, or Martin's rubber bandage. When circumstances render it impossible for the patient to rest in bed, the ulcer may be treated by strapping with adhesive plaster, and a bandage made of some elastic material to give support to the blood-vessels of the limb. The strips of adhesive plaster should be an inch wide and long enough to encircle two-thirds of the limb, and should overlap each other from below upward like the clapboards of a frame house. Concentric incisions made through the indurated tissues around an indolent ulcer may relieve the cicatricial pressure on the circulation and enable the edges of the ulcer to cicatrize.

The thickened margins, consisting of contracting cicatricial tissue, so interfere with the access of arterial and the egress of venous blood that the formation of healthy granulations is impossible. As much of the healing of all ulcers results from the reduction in size effected by the contraction of their bases, caused by the organization of the deep layers of the granulation-tissue into young connective tissue, rather than by epidermization, the fixation of the margins and base of a chronic ulcer to the subjacent parts must prevent healing. Upon this fact depends the utility of incisions a little distance from the margins of the ulcer. Blisters and the pressure of strapping owe much of their effect to the removal by absorption of the constricting effect of the old cicatricial tissue upon the circulation through the ulcer.

The phagedenic ulcer is due to infection by different forms of micro-organisms. When seen on the genitalia it usually follows venereal disease. In other regions of the body it may be caused by constitutional conditions combined with unhealthy surroundings. Intemperance and scurvy are predisposing causes, and when individuals affected in this way are crowded together in barracks or hospitals in time of war, such types of ulceration are not uncommon.

The surface of the ulcer is devoid of granulations, and is covered with a mass of sloughing tissue. Its edges are sharply defined and appear as if eaten out, and it spreads with great rapidity. The treatment consists in curetting by a sharp spoon and removal of the overhanging edges by the knife or scissors, followed by a thorough disinfection of the part by the application of antiseptic agents, such as pure carbolic acid, bromine, sublimate solution 1 : 500, and, if these fail, in the use of the Paquelin cautery. Constitutional treatment by means of tonics and stimulants and favorable hygienic surroundings should be employed. In mild cases pure iodoform or aristol or chloral (gr. x-xx @ 3j), or the potassio-tartrate of iron (gr. v @ 3j), will often effect a cure.

Ulcers depending upon *specific origin*, such as the strumous, scorbutic, lupoid, and syphilitic ulcers, will be considered more fully under their appropriate headings. The ulcerations seen in malignant diseases are chiefly carcinomatous. One of the most frequent forms is **rodent ulcer**, which is situated on the nose and cheeks, and often resembles specific or tuberculous ulcerations. It is, however, due to the breaking down of a genuine epithelial growth (Warren). Deep-seated cancers, when they reach the surface, enter upon an ulcerating stage, and may affect large surfaces in this way. Sarcomatous ulcers are comparatively rare.

SECTION II.—FISTULA AND SINUS.

A **FISTULA** is an abnormal opening into a normal canal or organ—*e. g.* the rectum or the duct of a salivary gland—or a communicating passage between two adjacent mucous cavities—*e. g.* the bladder and vagina, etc. Such a fistula when it communicates with an unhealed wound or old abscess-cavity is usually called a sinus. The terms are often used interchangeably. There is a great variety of fistulæ, each kind being named from the organ with which it communicates. Fistulæ may be due to congenital deformity, as a branchial fistula, which is formed by the non-union of one of the branchial clefts. They may be the result of injury or sloughing, as the salivary or vesico-vaginal fistulæ. Sinuses which result from the failure of an abscess to heal, and which have opened into some canal or cavity, are usually called fistulæ, as the urinary fistula and fistula in ano.

A **SINUS** is usually a canal opening upon the surface of the skin or a mucous membrane and terminating in the cavity of an old abscess. It may, however, result from the burrowing of pus beneath the skin, and will then form a tortuous series of canals extending in various directions. The failure of such a pus-cavity to heal is usually due to the presence of some secretion which pours into it, or to the presence of a foreign body, as a piece of dead bone, or to the inability of the walls of the cavity to collapse and come in contact with each other, as in empyema or abscess in the spongy end of a bone. Frequently the diseased condition of the walls of the sinus is an obstacle to repair. Many such sinuses are due to the presence of the bacillus of tuberculosis. In such cases they are lined with a membrane resembling that of cold abscesses, which must always be carefully extirpated or cauterized.

The **treatment** consists, first, in the removal of all irritating or diseased substances. It is often necessary to lay the fistula fully open and thoroughly to curette its walls before healthy granulations will spring up and aid in the healing process. Special fistulæ will be considered under their respective regions.

CHAPTER VII.

GANGRENE.

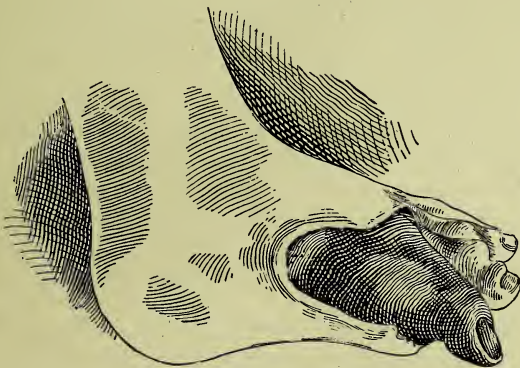
GANGRENE is a term employed to denote death of a part of the body in mass. Necrosis and mortification are terms used in a similar sense, but in surgery necrosis is often limited to death of bone: it is applied also to death of internal organs where, owing to the absence of bacteria, putrefaction does not take place and the dead mass is absorbed, new tissue growing in from the surrounding healthy parts to take its place. Gangrene results either from a cessation of the arterial blood-supply or from an obstruction to the venous outflow, or purely from a stasis of blood in the capillary vessels. It may also take place independently of any disturbance of the circulation by the direct action of destructive agents upon the cells of the tissues.

The most frequent non-traumatic **cause** of deprivation of arterial blood-supply is a diseased condition of the arteries, such as is seen in senile gangrene. It may also be due to arterial spasm, such as is produced by the action of ergot or disturbance in function of the vaso-motor nerves. Obstruction to the flow of venous blood is usually of a purely mechanical origin, as in strangulated hernia, or it may be the result of a venous thrombosis. Many causes act directly upon the tissues of the part, such as pressure, mechanical or chemical injuries, inflammatory swelling, heat or cold, and bacterial infection. The state of the tissue, due to an impaired nutrition of the body, is often favorable to the development of gangrene. This is observed during the progress of fevers or in individuals suffering from grave constitutional conditions, such as diabetes, or in parts deprived of their nerve-supply.

Typical gangrene occurs chiefly in two forms, the *moist* and the *dry*, which present striking contrasts to each other in their physical appearances.

Dry gangrene (Fig. 16), or mummification, is a condition produced by the loss of water from the tissues. The skin becomes black and wrinkled, and is often of a leather-like hardness. The amount of decomposition which occurs in this form is very slight, and the dead part in typical cases causes but slight disturbance to the adjacent living tissues. In this form of gangrene there is a gradual diminution in the supply of arterial blood, while the outflow of venous

FIG. 16.



Dry Gangrene (original).

blood continues unobstructed. In this way, aided by evaporation, water is gradually removed from the part.

The most typical form of this variety is known as **senile gangrene**, due to arterial sclerosis, the result of an obliterating endarteritis or of atheromatous changes in the walls of the vessels, combined with feeble heart-action. The calcareous condition of the arteries can often be easily detected at the wrist. The circulation in the capillaries becomes very feeble, and a slight bruise suffices to produce permanent stasis. Senile gangrene usually occurs in the lower extremities, involving the toes, where the circulation is least vigorous. The tibial arteries are frequently the seat of an endarteritis which materially diminishes their lumen, and a serious lessening of the blood-supply may exist in all the regions supplied by these vessels. The arterial blood may also be cut off by the presence of an embolus derived from valvular growths incidental to cardiac disease. In this case the disturbance in the circulation may occur so rapidly that mummification may not take place and moist gangrene will result. Dry gangrene may, however, be produced by embolism, and a large portion of an upper or lower extremity may occasionally be involved.

Symptoms.—The disease usually originates in some slight injury, as the bruising of a toe or the tearing of a portion of the nail, and is recognized by the change of color in the part, the dark-red congestion which at first appears gradually assuming a purple hue. The surrounding tissues are deeply congested, and the boundary-line between them and the dead tissue is at first imperfectly marked. The gangrene slowly advances beyond the limits of the toe in which it originated, and the adjacent toes may also become involved. When the progress of the disease is arrested, the inflamed parts set up a barrier of granulation-tissue and the **line of demarcation** is formed. The suppuration which follows separates the dead tissue from the living, and a spontaneous cure may be effected in this way. As the line of demarcation forms, the colors of the respective parts stand out in strong contrast. The inflamed tissues assume a brighter tint, while the purple hue of the dead part changes to black. An attempt on the part of the adjacent tissue to form a barrier to the advance of the disease often fails, and the gangrene spreads and may involve the whole foot, and even all the parts supplied by the tibial arteries. In the milder forms of the disease the amount of constitutional disturbance is slight, but when a large portion of a foot or leg is involved there is more or less septic infection, and a rise of temperature will indicate the presence of fever. This type is sometimes called *idiopathic gangrene*. The amount of pain is not great in this variety: during the early stages there may be a stinging or smarting pain, but after the formation of a line of demarcation this disappears. The pain in dry gangrene due to embolism is, however, much more severe, and generally is the cause of much intense suffering.

Occasionally obliteration of the arteries of internal organs may take place also, and infarctions with necrosis may be associated with senile gangrene.

Moist gangrene (Pl. VI) is caused by a sudden arrest of the arterial blood-supply or a similar obstruction to the return of the blood through the veins. It is likely to occur in deeply-seated tissues where evaporation cannot easily take place, as in strangulated hernia. Idiopathic gangrene may be of the moist type when the obstruction of the circulation is rapidly brought about and involves a large portion of a limb.

Severely contused or lacerated wounds of the soft parts, or fractures complicated with laceration of the large vessels, are a frequent cause of moist gangrene, known in this case as **traumatic gangrene**. Acute inflammations may be attended with such intense congestion and swelling that the circulation may be arrested over a considerable area, and death of the part will then occur. The same result will ensue from burns and frost-bites. In this form of gan-



Schultze, pinx.

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GANGRENE FOLLOWING A SHOT LACERATION OF THE FEMORAL ARTERY.

grene—**localized traumatic gangrene**—the tissues become soft and pulpy, the skin is discolored and changes to a deep purple or black or is covered with green and black spots. A thin brownish fluid filters through the skin, and raises the epidermis in the form of blisters or exudes from the open surface of wounds. Decomposition takes place through the agency of the saprogenic bacteria. In most cases a line of demarcation forms around the area affected by the destructive agency.

There is, however, another form of traumatic gangrene—**spreading traumatic gangrene**—in which the disease extends with frightful rapidity, due to an acute infectious process. These are cases in which the main artery or vein has been ruptured and the blood-supply of a portion of an extremity is suddenly cut off, followed by infection. In other cases acute inflammation of severe type, together with the intense septic infection, produces the death of the part. The gangrene spreads rapidly, even hour by hour, up the limb. Acute putrefaction sets in and spreads through the agency of micrococci or bacilli. The changes in color are rapid and striking: a deep bronze hue, like rind of bacon, spreads rapidly along the line of extension of the disease, and is accompanied by streaks of green and black. The part feels dense and brawny. The evolution of gas produced by the changes brought about by the putrefactive bacteria sometimes gives an emphysematous crackling to the subcutaneous tissue—a condition which is often observed somewhat in advance of the gangrenous changes. Constitutional disturbance is by this time very marked, and is due to the absorption of ptomaines, which the process of decomposition forces into the lymphatic channels and connective-tissue spaces or beneath fasciæ or along the course of tendon sheaths. As the parts through which the gangrene spreads are beyond the point of injury, no opportunity offers itself for the escape of these chemical poisons, and they spread upward through the circulation. The result is septicemia of a grave type, from which the patient succumbs unless the progress of the gangrene has been arrested by amputation. This type of gangrene is sometimes known as **fulminating gangrene** or **gangrenous emphysema**.

Fortunately, such grave results do not always follow death of a part from trauma. The gangrene may be limited to the part the circulation in which has been arrested, and a line of demarcation will soon separate it from the adjacent healthy parts. This form occurs frequently in a stump after amputation for railroad injury when the limb has not been removed at a point sufficiently remote from the seat of injury. A considerable portion of a limb may be destroyed by injury without a tendency of the gangrene to spread. In this case the numerous lacerations permit an escape of blood and serum, and the conditions for the development and spreading of the intense forms of decomposition are less favorable.

Smaller portions of dead tissue, such as the flap of an amputation-stump or masses of connective tissue or skin, are usually called **sloughs**. These are separated from the living parts by the septic inflammation which ensues and which results in suppuration; and, as the wound cleanses itself and the sloughs are thrown off, healthy granulations are found covering its surface.

Gangrene may result occasionally from *pressure*, but unless the latter is excessive this occurs only in parts where the circulation is already feeble and the conditions are favorable for complete stasis. **Decubitus**, or **bed-sore**, is produced in this way from long rest in the recumbent posture in individuals debilitated by fevers or long-standing chronic disease. When the slough has separated the ulcer thus formed may enlarge, and sometimes becomes quite formidable in size, and may be a complication more serious than the original disease. The

parts most frequently attacked are the integuments lying over the sacrum and coccyx, or, more rarely, the shoulder-blades and great trochanters. Sloughs may also be produced by bandages and splints when applied to a fractured limb. A frequent seat of such a "splint-sore" is the posterior aspect of the heel or the skin covering the tendo Achillis.

This form of local gangrene is much more likely to occur if the parts subjected to pressure have been deprived of their accustomed nerve-supply. *Neuropathic gangrene*, as it is sometimes called, is frequently observed after fractures of the spine. Sloughs will form with great rapidity under the heels and sacrum. This predisposition to death of the part has been ascribed to a functional disturbance of the vaso-motor nerves or to an abnormal action of the so-called "trophic nerves" which are supposed to preside over the nutrition of a part.

A type of gangrene more clearly due to abnormal vaso-motor action is the **symmetrical gangrene**, or **Raynaud's disease**. This appears most frequently upon the tips of the fingers or the toes. It may also be found in various other parts of the body, as the tip of the nose, the cheeks, the knee, and other salient points where the heat of the body is less than in deeper parts. It is due to a spasm of the vaso-constrictors brought about by reflex action. It is extremely rare in America. The "cold finger" often observed in bathers is ascribed to a similar cause. In symmetrical gangrene the parts affected are at first the seat of abnormal pallor and numbness, then of a purplish discoloration, and a small slough finally forms which is thrown off and is followed by healing of the sore thus produced. Several fingers are simultaneously affected on both hands.

A similar spasm of the vaso-motor nerves is produced by the prolonged use of *ergot*, and epidemics of gangrene have been observed in France and elsewhere which were due to the presence of ergot of rye (*Secale cornutum*) in the grain employed as food.

Individuals affected with diabetes are frequently attacked with **diabetic gangrene**. This is often seen in elderly people subjects of the disease, and may be mistaken for senile gangrene. The presence of sugar in the urine should therefore be carefully sought for. Operations upon such persons are supposed to be followed by gangrene or sloughing of the lips of the wound, and it is advised by some authorities to abstain from surgical operations if they can be avoided. A more extended experience with aseptic surgery, however, will probably not bear out this view. In one case known to the writer both legs were successfully amputated for diabetic gangrene. There was an interval of one or two years between the two operations.

Noma, or **cancrum oris**, is a gangrene of the cheek usually occurring in children as a complication of the eruptive fevers—*e. g.* scarlatina. It is the result of a gangrenous stomatitis, and is of bacterial origin, producing capillary thrombosis. The disease may even attack the bone, and in the majority of cases is fatal. If recovery takes place a large defect usually results which must be restored by a plastic operation.

Gangrene from **frost-bite** may result partly from the intensity of the cold and partly from the enfeebled condition of the individual. The part at first is blanched, but subsequently turns black. It may assume the dry or the moist condition. It may be limited to the toes, which are the most frequent seat of this form of gangrene, or the whole foot may be involved. It is frequently quite superficial, and no attempt at surgical interference should be made until the line of demarcation is clearly established.

Treatment.—The prophylactic treatment of gangrene consists in the removal, as far as possible, of the causes which may favor the development of

gangrene, and in the adoption of such measures as will promote the circulation of blood in the part.

If inflammation threatens to terminate in gangrene, free incisions may relieve the tension sufficiently to avert the impending danger. Division of the constricting ring of a strangulated hernia will remove the obstruction to the circulation in the bowel.

If, however, the obstruction cannot be removed, as in embolism or thrombosis, attention must be given to the establishment of the collateral circulation in the limb by favoring as much as possible the flow of venous blood and preserving the warmth of the part. Moderate elevation of the limb and gentle massage may favor the return of blood through the superficial veins. Slightly flexing the joints will favor the flow of blood through the larger vessels. An equable temperature of the desired degree may be maintained by enveloping the limb in dry cotton-wool, which should be loosely applied.

Minute abrasions or sores about the nails in feeble individuals should receive careful attention, but meddlesome interference should be avoided, as these are frequently the starting-points of senile gangrene. If death of the part is unavoidable, great care should be taken to prevent infection and decomposition. The gangrenous part must be disinfected with the same care as for an operation, and then be kept dry and odorless. Antiseptic dressings containing powders, as iodoform, boric acid, or aristol, should be applied. If the fluid products of decomposition are retained beneath the surface, they should be released by incisions into the gangrenous tissues, or if pus is burrowing, openings should be made into the living tissues to evacuate it.

It was at one time the almost universal custom to wait for the line of demarcation to form in senile gangrene before making any attempt to remove the dead mass, and as a rule it is better to adopt this plan. If the gangrene shows a disposition to localize itself, it would be bad practice to interfere in any way with the processes that are going on in the enfeebled living tissues, as any disturbance of them might cause the gangrene to spread still farther. As soon as the gangrene involves the sole or the dorsum of the foot, the question of amputation will become one of vital importance. In determining the point at which to amputate the pathology of the disease should be kept in mind. If we have to deal with a disease of the tibial arteries, it will be necessary to decide at what point in their course the circulation is of sufficient volume to maintain the life of the stump. Never amputate low down. Heidenhain recommends amputation of the thigh as close above the condyles as possible. An amputation of the leg below the tubercle of the tibia in some cases may be sufficiently high, but generally it is necessary to remove the leg at or above the knee. The latter point is often to be preferred, since the flaps will then be largely nourished by branches of the profunda femoris, which is rarely thrombosed. A considerable number of cases which in former times were allowed to die without surgical interference are now undoubtedly saved by amputation.

In gangrene from embolism amputation should be performed well above the gangrenous area as soon as the extent of the gangrene has been determined by the establishment of a line of demarcation.

In traumatic gangrene involving portions of the integuments it is not necessary to attempt removal of the sloughs until the line of demarcation indicates clearly the extent of the injury. A partial removal of the dead skin may, however, favor drainage of the parts below.

When a portion of a limb is destroyed by injury, the question of an immediate amputation should first be carefully considered. If this is not done and

gangrene sets in, and there are any signs of its spreading, this should prompt the surgeon to urge the necessity of amputation.

If the gangrene is localized, the general condition of the patient will enable one to decide whether it is best to remove the dead portion of a limb immediately or not. The effect of the presence of such a putrescible mass must be weighed against the danger of an operation in a patient suffering from shock and possibly other severe injuries. The conditions of each case will enable one to decide whether it is better to remove the limb at the line of demarcation or to amputate through sound tissue.

In spreading traumatic gangrene it will of course be necessary to amputate instantly and far away; that is, sufficiently high to remove all tissues involved in the septic process. There is perhaps no affection in the whole domain of surgery which demands such prompt interference in order to avert impending death.

The constitutional treatment consists in attention to the condition of shock and in supporting the strength of the patient. Absolute rest, careful nursing, and a diet that will be nutritious without interfering with the digestive functions will best meet these indications. Alcoholic stimulants are also of great value and should be used freely, but with due regard to the patient's powers of assimilation.

The treatment of bed-sores is largely prophylactic by frequent change of posture, and—thanks to the present system of nursing—the attention of the physician or surgeon is now rarely called to this affection. Dry dressings are to be preferred, as moisture favors the enlargement of ulcers produced in this way. Mechanical support to relieve pressure and strict attention to antisepsis will usually arrest the progress of the disease.

The rules for the treatment of diabetic gangrene vary but slightly from those laid down for senile gangrene. The disease is not necessarily a contra-indication to amputation. In any event a most careful attention to the diet will form an important factor in the prognosis of the case.

Little operative interference is necessary in symmetrical gangrene: the main points in the treatment of such cases are attention to the diet and hygienic surroundings and the administration of tonics.

Hospital gangrene is one of the traumatic infective diseases, and is characterized by a septic inflammation of the surface of a wound, causing ulceration and the formation of sloughs, and is accompanied by more or less constitutional disturbance. The disease at the present time has almost completely disappeared, owing to the general employment of aseptic and antiseptic treatment. It formerly occurred when patients were crowded together in small quarters with insufficient attendance and food and under poor hygienic conditions. The principal varieties usually described are the diphtheritic, the ulcerating, and the pulpy forms. The disease has been regarded by some as identical with diphtheria, but, as the latter disease has continued its activity for twenty years after gangrene has disappeared, this assumption does not appear probable. No bacteriological studies of value have been made, but some writers report large numbers of streptococci, and Koch produced in mice a disease resembling hospital gangrene in which the streptococcus was found.

The diphtheritic form is characterized by the occurrence of coagulation-necrosis in the granulations. There is, moreover, less inflammation in the margin of the wound in proportion to the depth to which the tissues are involved. The discharge is at first diminished, but later becomes more watery in character, the sloughs separate, the wound has a crater shape, and its edges are eroded. In the ulcerating form there is a progressive enlargement of the

wound, chiefly on the surface, accompanied by an unhealthy or grayish discoloration of the granulations. The edges break down, recede daily, and have a gnawed look, and the wound may finally become very large. This type is sometimes called phagedena. The pulpy form is more common in epidemics. The granulations swell, become œdematous and necrotic, the surface of the wound is soon enormously swollen, and a fetid discharge wells up in large quantities from its depths. Its margins become swollen, everted, and are exquisitely sensitive. There are great discoloration and swelling of the surrounding parts, with profound constitutional disturbance. The wound increases in size with great rapidity, and secondary hemorrhage often occurs. Joints are laid open and muscles dissected out as the disease spreads, and if the disease is not arrested, the patient finally succumbs to septicemia.

The prophylactic treatment consists in the application of the rules of aseptic surgery, and when, as in time of war, these cannot be observed with sufficient care, in avoiding the accumulation of great numbers of patients in confined quarters and their prompt isolation if the disease appears.

The local treatment consists in a thorough disinfection of the surface of the wound and the surrounding infected tissues. This may be accomplished by removing the diseased tissue with the curette or scissors, and by the subsequent application of the cautery, bromine, fuming nitric acid, or acid nitrate of mercury. The operation will require anesthesia, as even the ordinary dressing of such a wound is exceedingly painful. For milder cases a weak solution of nitric acid may be used with advantage, or the wound may be freely dusted with iodoform. Perchloride of iron was used with success by the French in their last war. Whatever the agent employed, it must be applied as directly as possible to the living tissues. The constitutional treatment consists in the free use of stimulants and supporting diet. An entire change of the patient's surroundings may bring about a prompt improvement. Epidemics have been broken up by moving the patients from the wards of a hospital into tents. All clothing and bedding and dressings should be changed at the same time. Amputation may be sometimes called for, and can be successfully done under strict antiseptic precautions. The disease being distinctly contagious, isolation and the non-use of sponges, towels, basins, etc., from patient to patient, are evidently necessary.

CHAPTER VIII

THROMBOSIS AND EMBOLISM.

A **THROMBUS** is a clot of blood which forms in the blood-vessels during life. An **embolus** is a detached fragment of a thrombus, a fragment of a vegetation on one of the valves of the heart, a globule of fat or of air, etc., which has been transported to some other part of the arterial system and acts as a plug.

Coagulation of blood may take place in one of two ways: When blood is allowed to remain stagnant in a flask, the clot which forms is nearly as large as the whole amount of blood, and is of a deep-red color, which still remains after the serum has been pressed out. It contains chiefly red corpuscles held together by fibrin. It is such a clot that is found in the *red thrombus*.

The clot from blood beaten with a stick loses its red color, and is of a yel-

lowish-white tinge, consisting of a tough mass of fibrin containing but few red corpuscles. As has been shown elsewhere, this coagulum contains chiefly broken-down white corpuscles which have yielded up their fibrin-producing material. This is one way in which a *white thrombus* is formed.

The **cause** of coagulation of blood in the vessels was thought by Virchow to be a slowing of the current, but it has been shown that the blood may be kept stagnant between two ligatures and yet no thrombus form, provided the vessel be kept aseptic and uninjured. Coagulation appears to be due to slowing of the current if these conditions are not fulfilled, and also to roughness of the inner wall of the vessel, to injury to the wall of the vessel, or to septic infection. The blood-plaques or third corpuscles play an important part in the process of coagulation of the circulating blood. When a roughness exists on the vessel-wall and the current is less rapid than usual, the blood-plaques leave the center of the stream and accumulate at the spot in question. Numbers of leucocytes are also arrested and become attached, and form a little hill which projects into the lumen of the vessel (mural implantation). The cells by a process of "conglutination" form a viscous mass in which little cell-structure is seen. This is another process by which a *white thrombus* is formed.

Mixed thrombi are those white thrombi in which 'an unusually large number of red corpuscles are seen here and there in clusters. The white or mixed

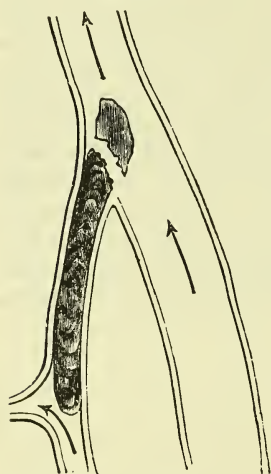
thrombus forms from flowing blood, and is the variety usually seen in the blood-vessels. Red thrombi are more rarely seen in the living body: they occur chiefly in vessels subjected to septic infection; they may also be found plugging the mouths of vessels which have been cut and have bled freely.

The white thrombus usually begins as a parietal thrombus, but it may finally grow to sufficient size to obstruct the lumen of the vessel by successive deposits and may extend some distance. It is then called an obstructing thrombus. After a thrombus is formed it may undergo several changes. It may become organized, young tissue growing into it from the vessel-walls and forming a cicatricial tissue; as portions of the clot are disintegrated and absorbed, spaces are left in the newly-formed tissue, which has a spongy consistency. It is then said to be "canalized." Blood flows through the new channels, and the circulation is partially re-established in this way. At other times organization does not take place. The fibrin and leucocytes break up into a fatty mass which forms a slimy fluid in the inner layers of the thrombus, and the thrombus is thus broken up. When

septic infection takes place, we have broken-down leucocytes mingled with bacteria and the various ingredients of the clot, and a "puriform softening" or "suppuration" of the thrombus takes place. A thrombus thus disorganized may break up into masses which become detached and are swept off into the circulation as infective emboli; or a thrombus which has developed so as to project into a large vessel may lose a portion of the protruding clot, and so give rise to embolism (Fig. 17).

Thrombi are found in the heart and veins, and also in the arteries. Emboli are found in the arteries, but also in the veins of the liver. When an embolus is lodged in a "terminal" artery, the part supplied by this vessel is

Fig. 17.



A Thrombus in a Vessel. The detached fragment about to be carried away in the direction of the blood-stream is an embolus (Billroth).

deprived of its circulation and becomes anemic, or occasionally a backward flow of blood takes place from the veins into the emptied vessels and a congestion with extravasation or a "hemorrhagic infarction" occurs. If the embolus is an infected one, suppuration will take place and a **metastatic abscess** forms.

Many of the emboli which are detached from veins become lodged in the capillaries of the lung, but very small emboli may pass through them and enter the general arterial system.

Emboli may be formed from other substances than blood-clot. When tissues containing fat are broken down by injury, drops of fluid fat enter the circulation and are lodged in the pulmonary capillaries. **Fat embolism** thus may follow fracture of a bone, especially at the spongy ends of the long bones. Dyspnea, and even death, may occur from this accident. **Air embolism** may occur through wounds of veins in the neck or axilla and through the uterine venous sinuses. A considerable quantity of air may be introduced without injury. The emboli will then be distributed in the capillaries of various parts of the body and eventually disappear; but if a large quantity is introduced at once, the heart may be distended with air and death will occur.

Emboli may sometimes travel against the current by force of gravity, as in the vena cava and other large veins of the lower part of the body.

The **treatment** of thrombosis or embolism is mainly prophylactic. Care should be taken that the thrombus does not give rise to emboli. The part therefore should be kept at rest until organization or absorption of the thrombus has taken place.

CHAPTER IX.

SEPTICEMIA.

SEPTICEMIA is a disease due to the absorption of the products of putrefaction into the system, or to the introduction into the blood and tissues of bacteria which rapidly multiply there. It is characterized by grave constitutional disturbance, with acute fever, disorders of the nervous system, inflammation of certain viscera, and a local infection of the wound. The nature of the poison which produces the disease is not yet fully understood. Experiments on animals have shown that there are *two varieties* of this form of blood-poisoning. In certain cases symptoms supervene immediately upon the inoculation, and the animals die of a chemical poison, no bacteria being found in the blood or tissues (**sapremia**, **toxemia**, or **septic intoxication**). In other cases the symptoms come on less rapidly, and death is caused by the presence of bacilli or micrococci in the blood (**septic infection**). Many observers have sought for bacteria in the blood in the septicemia of man, and micrococci have been found occasionally, but not with sufficient regularity to identify them with the disease. Since the existence of ptomaines as a product of decomposition has been understood, it is generally recognized that the poisons elaborated by bacteria play a prominent part in the production of the disease.

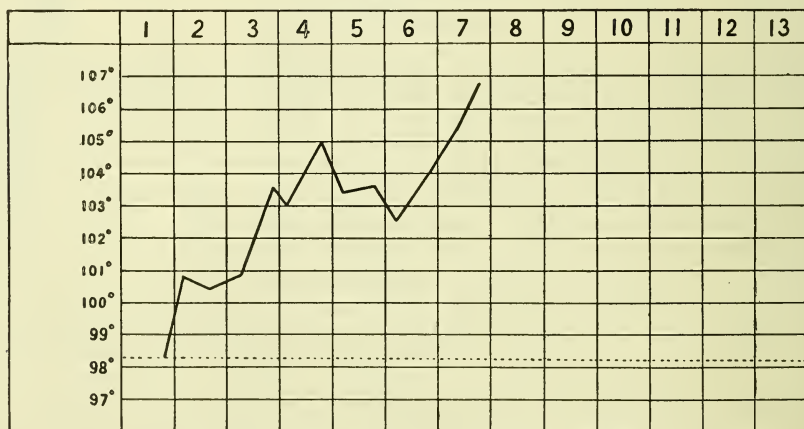
Clinically, we find the same two types of the disease in man. One is due clearly to the absorption of a chemical substance or ptomaine. The symptoms of this variety cease as soon as further introduction of the chemical substance is prevented by a cleansing of the wound. In the other variety there are progressive changes coming on gradually, as in the bacterial type in animals,

and continuing frequently to a fatal termination in spite of efforts to check them by treatment of the wound. This variety suggests the action of bacteria, and these organisms are found in some cases, those most frequently observed being the streptococci.

The method by which infection of the system takes place is through a wound which is undergoing putrefactive changes owing to decomposition of the tissues (sapremia), or through the diffusion and multiplication of the bacteria from an infected wound, even of a trivial character (septic infection). This is most likely to occur before the wound has become covered by healthy granulations. It may also take place through the intestinal mucous membrane (sepsis intestinalis), as in cases of tyrotoxicon poisoning, and more rarely through the urogenital tract.

Sapremia.—The toxic form of septicemia is frequently seen in obstetrical cases in which putrefaction of retained clots or placenta has taken place within the uterus. The poison may be absorbed through the mucous membrane of the vagina or uterus, or through open wounds in these regions or through the uterine sinuses. The disease is ushered in with a sharp rise of temperature, the chill usually being absent. The temperature continues high, and is accompanied later with delirium. The skin is cold and clammy, and there is more or less tendency to diarrhea. A prompt removal of all decomposing substances from the interior of the uterus will be followed in a few hours by a disappearance of all alarming symptoms. Conditions favorable for such a type of poisoning are rare in general surgery, although a large, ill-drained wound, or decomposition occurring in the contents of a psoas or other abscess, is a not uncommon cause: these conditions also may be found in abdominal wounds where extensive injury of the peritoneum has favored oozing and the accumulation of blood-clot in the peritoneal cavity.

FIG. 18.



Temperature Chart of a Case of Septicemia (original).

Symptoms of Septic Infection.—In true septicemia or septic infection the development of the disease is more gradual. The fever curve is of the continuous type as in sapremia, and as the fatal end approaches the temperature will range higher. In certain cases the temperature is, however, subnormal, as is seen occasionally in strangulated hernia or in gunshot injuries of the abdomen. There is great prostration with headache and anorexia, and a typhoid condition supervenes which renders the patient indifferent to surroundings.

Diarrhea frequently develops, and may at times be accompanied with vomiting, but it is usually not severe. There is a tendency to the enlargement of the lymphatic glands throughout the body, and more particularly of the spleen. The skin is pale and dusky, but an icteric tinge is not so common as in pyemia. The hue is due to the rapid deterioration of the blood caused by the presence of the virus. A scarlet eruption may occur resembling closely that seen in scarlet fever. The skin in the early stages is hot and dry, but later is bathed in perspiration, and finally becomes cold and clammy. The sallow hue becomes more marked. The senses are dulled and the countenance is listless. The tongue is covered with a brownish fur. The pulse is now weak and rapid; diarrhea increases, and the urine is concentrated and scanty. Delirium is followed by coma, and the patient becomes moribund.

The **pathological changes** observed in the internal organs are slight. The blood is thin, of a tarry color, shows no tendency to coagulation, and contains numbers of micro-organisms. Cloudy swelling of the liver or kidneys is usually found. In the alimentary canal there is evidence of a gastro-intestinal catarrh. The mucous membrane is swollen and mottled, and punctiform hemorrhages are found at certain points. Enlargement of the lymphatic glands is noticeable, particularly of the spleen. The wound occasionally is in an extremely septic condition; at other times there is little evidence of any pathological change. When septicemia follows the infliction of a *dissecting wound* or other injury by which material already loaded with the bacteria of putrefaction is inoculated into the tissues, there is a diffused septic inflammation about the wound which develops rapidly and spreads along the line of lymphatics leading from the part, as shown by red streaks running to the adjacent chain of lymphatic glands. In very malignant cases œdema of the adjacent tissues involving a considerable area will be observed.

The original focus from which septicemia is sometimes developed may be a wound involved in gangrene or erysipelas, or some deep-seated infective inflammation around the kidney or appendix or in the medulla of bone, or a tract of connective tissue infiltrated with foul urine.

The principal **diagnostic signs** of septicemia are the continued fever, the absence of chills, the peculiar condition of euphoria or apathy, the intestinal catarrh, and the presence of an increased area of dulness about the region of the spleen. The general appearance of the patient and the condition of the pulse will prove valuable guides in enabling the surgeon to distinguish between this type and the less malignant forms of surgical fever which occur independently of suppuration. The condition of the wound and the presence or absence of pronounced suppuration will also aid in the diagnosis, although it should be remembered that septicemia may develop even during the suppurative process, provided the conditions for putrefaction exist in the wound.

The **prognosis** of the disease is always grave, but its duration may vary greatly according to the intensity of the virus. In sapremia of a pure type the prognosis is much more favorable, as the fever will disappear as soon as the local mass of putrefaction is removed; but inasmuch as it is quite difficult to say in any given case whether there is not also a true septic infection in addition to the toxic poisoning, the opinion expressed by the surgeon must be a guarded one. The weakness and frequency of the pulse, the extremes of temperature, and the mental condition are important symptoms as guides in estimating the gravity of a given case. In the acute type we have to deal with one of the most fatal of diseases. When the disease takes a more chronic course, as it occasionally does, we may have reason to hope for a cure, although a very large proportion of these cases also terminate fatally.

Treatment.—The prophylactic treatment consists in the application of the rules of aseptic and antiseptic surgery, which have greatly diminished the number of cases of septicemia at the present time. When the disease makes its appearance the attention of the surgeon should at once be directed to the condition of the wound, and no time should be lost in carrying out a thorough disinfection of its entire surface. Stitches should be removed and sinuses carefully exposed. All collections of blood-clot or decomposing fluids should be washed out with corrosive sublimate, 1 : 1000, and subsequently the tissues should be disinfected with strong solutions of carbolic acid (1 : 20, or pure crystals) or chloride of zinc (1 : 10). The wound can then be packed with gauze containing a large amount of iodoform powder, or antiseptic poultices can be applied to favor a free discharge (carbolic acid 1 : 1000, or corrosive sublimate 1 : 20,000). When the wound has deep recesses or pockets which cannot easily be reached, irrigation with boiled water, boric acid (4 per cent.), or a saturated solution of acetate of aluminum may be employed. In septicemia following laparotomy the prognosis is so grave that little success can be expected from local treatment. An attempt to save life, however, should be made by reopening the wound and by a thorough hot-water douching of the peritoneal cavity, followed by drainage. In sapremia douching of the wound is generally followed by an immediate, and frequently by a permanent, improvement. In puerperal fever from this cause the antiseptic washing of the uterus is productive of most satisfactory results.

The constitutional treatment consists principally in the fearless use of stimulants. Very large quantities will be assimilated under these conditions without producing alcoholism. The use of drugs taken internally for their antiseptic action has not proved sufficiently successful to encourage a further trial at present. The heart's action should not be hampered by any depressing agents. On the other hand, a free use of digitalis and other heart tonics may prove a valuable aid to stimulation. One of the best is strychnia administered subcutaneously in doses of gr. $\frac{1}{40}$ – $\frac{1}{30}$ every two to six hours. Nutritious diet should be administered in such form as not to impede digestion and to favor rapid assimilation.

CHAPTER X.

PYEMIA.

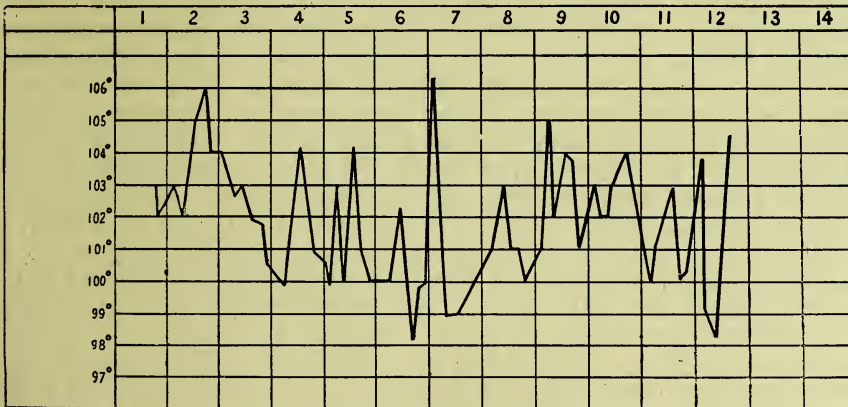
PYEMIA is an infective disease developed during the process of suppuration, and is due to the absorption of pyogenic organisms into the circulation. It is characterized by the development of *multiple* or *metastatic abscesses* in different portions of the body, frequent chills, and an intermittent type of fever. The name given to it by Piorry is derived from πύον, pus, and αίμα, blood. The old view that pus formed in the wound obtained an entrance into the circulation has long since been abandoned, but we now know that certain elements of pus may find their way into the circulation and produce metastatic abscesses.

Etiology.—Reliable investigations on the special forms of bacteria which are found in cases of pyemia have been made only within the last decade. Among the most important are those of Koch, who succeeded in producing the disease in rabbits. He found in the vessels chain-like cocci which caused the blood-corpuscles to adhere and form thrombi. Ogston showed that the pyogenic

cocci were partly anaërobic, and grew more readily in deep sinuses and pockets, and thus readily obtained an entrance into the circulation. The examination of the blood of individuals ill with pyemia has shown that both the staphylococcus and the streptococcus may be the active agents in the formation of metastatic abscesses. When the conditions become favorable for an unusual development of these bacteria, the barrier of granulation-tissue does not prevent their growth into the surrounding tissues. From these they obtain an entrance into the system through the blood-vessels more often than through the lymphatics. Coming in contact with the wall of a vein, an infective inflammation is started which terminates in a thrombo-phlebitis. Rough places are formed on the intima which lead to the formation of parietal thrombi and the subsequent development of an extensive thrombus, which undergoes a puriform softening; or a zoöglea mass of micrococci may accumulate on the inner surface of the wall of the vein and may be swept off into the circulation as an embolus. Minute emboli may pass the pulmonary capillaries, and, entering the arterial system, become lodged in the glomeruli of the kidney or other capillary districts, or even in the valves of the heart.

Larger emboli detached from the softened thrombus may be lodged in the capillaries of the lung. At all these points infective inflammation and supuration may occur, and **metastatic abscesses** are thus developed. As a rare occurrence pus from an abscess may find its way directly into the circulation by the breaking of the abscess into a vein. The bacterial infection may also occasionally take place through the lymphatic system. The so-called spontaneous pyemias occur by a process of intravascular infection. In individuals in feeble health micrococci are sometimes found circulating in the blood temporarily. If under such conditions a slight internal bruise or wound is received—as, for instance, in the medulla of bone from a fall—the micro-organisms gain an entrance from the blood-vessels into the injured part, and an acute osteomyelitis is developed which may become the starting-point of a pyemia.

FIG. 19.



Temperature Chart of a Case of Pyemia (original).

Symptoms.—The first symptoms of the disease are noticed usually in the second week of the healing process at a period when suppuration has been fully established. These are ushered in with a chill which may be of a widely varying degree of intensity. The occurrence of such a symptom should always put the surgeon upon his guard, and the wound should be carefully inspected.

An increase in the local inflammation may or may not be discovered. A second chill will probably occur on the following day, and frequent repetition of the chill is a characteristic feature of the disease. The fever is of an irregular intermittent type, and varies not only according to the frequency of the chill, but has an almost hourly variation of its own. The undulating character of the daily fever curve is quite characteristic of pyemia, and a fall to the normal point in acute cases is rarely observed (Fig. 19).

The development of metastatic abscess is indicated by a febrile exacerbation and by the symptoms of local inflammation. A sharp pain in the side, with respiratory disturbance and fever, accompanies the formation of an abscess in the lung or a septic effusion into the pleura. The joints are also a frequent seat of inflammation, and this is accompanied with considerable swelling of the adjacent soft parts. The next point attacked may be the parotid gland. The skin is always markedly discolored, and frequently assumes a deep yellow hue. With the development of the icterus there is already marked emaciation, which, in chronic cases, is extreme. Erythematous rashes, which subsequently become pustular, are occasionally noticed. The tongue is furred and coated, but may vary greatly in appearance. The pulse is rapid, and as the disease progresses becomes weaker.

The mental condition of the patient is usually not affected. There is, however, in the later stages great hyperesthesia, and such patients are constantly complaining of pain in various parts of the body, due not only to metastatic inflammations, but to the sensitiveness of the nerves. An examination of the heart-sounds may reveal the presence of an infective endocarditis. Brain symptoms are rarely present, although metastatic inflammations may occur in the brain, and hemiplegia may result from emboli due to the endocarditis. The mind usually remains clear until the development of delirium and coma in the latest stages of the disease.

The duration of the disease will vary according to the acuteness of the attack. Chronic pyemia may be prolonged for weeks or even months. Usually in acute cases a fatal termination will be reached in the course of a week or ten days.

Pathological Anatomy.—The wound is of a gangrenous color or odor, or the granulations are still present and have a glazed and indolent appearance. Extensive thrombi are found in the adjacent veins. In amputation-stumps of the lower extremity the femoral vein may be filled as high as Poupart's ligament with a puriform mass. In the lungs metastatic abscesses are found chiefly in the lower lobes and near the pleural surface. Infarctions are also not infrequent. The pleural cavity may be the seat of a serous effusion. The liver is in a state of cloudy swelling, and, less frequently than in the lung, metastatic abscesses are found. Miliary abscesses may be found in the kidney, in the valves of the heart, in the intestinal mucous membrane, and, in fact, in almost any organ of the body. Metastatic inflammations are also seen in the connective tissue and in the joints. The synovial membrane is at first congested, and later suppuration may occur. The knee and shoulder are the joints most frequently affected. The bones may also be the seat of metastatic foci. Icterus is caused by the breaking down of the red blood-corpuscles, and is said therefore to be hematogenous (*i. e.* of blood origin).

Diagnosis.—In the early stages of traumatic inflammation a chill may be due to the development of some other form of infective disease, as erysipelas, but repeated chills are characteristic only of pyemia. The clearness of the mind, the hyperesthesia, the emaciation and great prostration, are all well marked and significant in this disease. The presence of metastatic abscess and joint inflammations when they finally occur leave no doubt as to the diagnosis.

The **prognosis** is exceedingly grave. It has been maintained that no case of pyemia ever gets well, but many cases of undoubted recovery have been reported, particularly in the chronic forms of the disease.

Treatment.—The prophylactic treatment consists in the prevention of suppuration. The antiseptic treatment of wounds has almost abolished the disease in hospitals, where it was formerly of frequent occurrence. When the first septic disturbances have developed in the wound and adjacent veins an attempt should be made to arrest the further progress of the disease by a thorough disinfection, not only of the wound, but of the interior of the vein. Such attempts have been successfully carried out in thrombosis of the lateral sinuses and jugular veins following suppuration in the mastoid cells. If the interior of the vein cannot be thoroughly disinfected, a ligature may be placed upon it at a point between the puriform thrombus and the heart. When the infected area is seated in an extremity amputation may be performed, provided the surgeon can be reasonably certain that the thrombus does not extend above the point selected for the operation. When it is possible all metastatic abscesses or suppurating joints should be laid open and thoroughly disinfected. Drugs are of little use in the internal treatment of the disease. Antipyretics depress the heart's action. Carbonate of ammonium and digitalis are more likely to be of service during the stage of prostration. Alcohol should be given freely, and in as large quantities as the patient will bear. Easily-digested food should also be administered unsparingly. If the patient is in a hospital he should be immediately isolated from all other patients, and as strict a quarantine as possible of those in attendance should be preserved. Ventilation should be free, and the patient may be placed in a tent, or even for a portion of the time in the open air, in certain cases.

CHAPTER XI.

ERYSIPELAS.

ERYSIPELAS is an acute infective inflammation spreading along the upper layers of the integuments of the body and mucous membranes through the lymphatic system. It is accompanied by a remittent type of fever and shows a tendency to recur. The name is probably derived from *ἐρυθρός*, red, and *πέλλα*, skin. Erysipelas was known to the ancients, but authentic accounts are of comparatively recent date. Severe epidemics of erysipelas raged in France in 1750, in Great Britain in 1800, and in 1842–43 both Europe and America were visited by an epidemic of a most virulent type. Since then there are no records of epidemics of similar severity. Although much less frequently met with since the introduction of the antiseptic treatment, it is the most common of the traumatic infective diseases seen at the present time.

Etiology.—The organism which is the cause of the disease is the *streptococcus erysipelatis*. This has been abundantly proved by experiments in animals and man. Opinions vary as to the identity of the streptococcus pyogenes with the streptococcus of erysipelas. The cocci grow in serpentine chains; each measures from 0.3 to 0.4 micro-millimeters in diameter. These cocci are said to be somewhat larger than the streptococcus pyogenes, but smaller than the staphylococcus. They are found in the capillary lymphatics of the

skin chiefly, but they may also be seen occasionally in the capillary blood-vessels. They are most active near the margin of the erysipelatous blush, and the lymphatics are crowded with them at this point. They are not found in any numbers in the circulation, but it is probable that the constitutional disturbance is due to their presence or to the presence of ptomaines in the blood. The organism usually obtains an entrance through a wound. In idiopathic erysipelas, when no wound is seen, it is probable that small abrasions of the skin are the route through which the virus enters the body. Probably also cases of internal infection occur, the organisms having been previously absorbed through the respiratory or digestive tract.

The *contagiousness of erysipelas* had been abundantly proved clinically before the nature of the poison was understood. The disease has been conveyed to a large number of children through the medium of vaccine virus taken from a child affected with erysipelas. Instances of erysipelas carried from a distance to certain localities where no such disease had existed previously, and producing there an epidemic, abound in literature. The close relationship between erysipelas and puerperal fever has long been recognized, and examples of the transmission of the virus of erysipelas to puerperal women by the medical attendant, and the consequent production of puerperal fever, are far too numerous. Both diseases are produced by the streptococcus, and experiment has shown that this organism can be cultivated from a puerperal case and can then be injected into rabbits, producing erysipelas. It seems probable that the disease is more prevalent at certain seasons of the year, particularly in the early spring months.

Symptoms.—This disease is usually ushered in with a chill which is accompanied with vomiting or more or less gastric disturbance. In children a convulsion not uncommonly takes the place of the chill. An examination of the wound at the time shows no perceptible change, although the nearest lymphatics are apt to be enlarged, and it is not until the end of twenty-four hours or longer that a blush is seen in the skin at this point. There is an increased tension in the part, accompanied by an itching or burning sensation. When the local inflammation has developed the color of the skin is a yellowish red, and there is considerable infiltration of the inflamed part, which has a doughy feel. The area invaded is well defined and its margins are quite irregular, presenting a zigzag outline. During the height of the inflammation vesicles form on the surface and sometimes become quite large. When resolution takes place there is considerable desquamation. The inflammation does not remain long in one spot. It spreads widely, and may involve large areas or even the whole surface of the body. In the mean time, at the end of three or four days the part first attacked begins to improve. During the height of the inflammation the constitutional disturbance is well marked. The temperature ranges from 102° to 104° F. The pulse is rapid and shows a tendency to become weak. The tongue is heavily coated and the urine is charged with urates. With each fresh outbreak of the cutaneous inflammation there is an increased pyrexia and the fever curve presents a most irregular outline. There are marked remissions, but usually no return to normal until the dermatitis has subsided. The duration of the disease is quite uncertain. In favorable cases it will last no longer than a week or ten days, but frequently the attack may last a month. Toward the close of the disease when the case is terminating favorably there is usually a tendency to subnormal temperature, showing the great prostration which the disease has produced. This depression of the vital powers is a feature of the affection which it is always important to bear in mind.

Varieties.—When the virus does not confine itself to the superficial capillary lymphatics, but spreads to the subcutaneous connective tissue, we have the variety known as **phlegmonous** erysipelas. Under these circumstances suppuration, which is extremely rare in ordinary erysipelas, is likely to occur. The foul, acrid, and thin pus infiltrates large areas, and there are sloughs of the connective tissue which are discharged in masses. In some of the severe epidemics of this type the muscles were attacked and the periosteum was destroyed, giving rise to necrosis. Gangrene of the skin may also occasionally occur from deprivation of blood due to death of the underlying connective tissue. The presence of a phlegmonous inflammation is indicated by the increased amount of local swelling and constitutional disturbance. Fluctuation or bogginess is soon felt, and if the pus is not liberated by incision it burrows freely in all directions.

Phlegmonous cellulitis, or inflammation of the subcutaneous cellular tissue, is regarded as identical with phlegmonous erysipelas by many writers. It is probable that the streptococcus rather than the staphylococcus is most frequently found in this form of inflammation, but the question must remain open until the identity or non-identity of the streptococcus pyogenes and the streptococcus erysipelatis is settled. Clinically, the two types are readily distinguished by the absence of cutaneous erysipelas in phlegmonous cellulitis.

There are other forms of rapidly-spreading inflammations of the skin and cellular tissue, particularly those which follow infected wounds of the fingers or hand, which are regarded by some authors as akin to erysipelas. These at times take the form of lymphangitis; at other times they occur as acute swellings of the integuments and connective tissue, extending with great rapidity, showing but slight tendency to suppuration, and frequently terminating fatally with symptoms of acute septicæmia. They are probably due occasionally to infection with streptococci or with saprogenic bacilli.

Facial erysipelas, which at one time was regarded as idiopathic erysipelas, is now supposed to be due to infection through some slight wound or abrasion on the face. It usually begins with a blush near the root of the nose or the lachrymal duct and spreads laterally toward the ears. The color is a scarlet red, and the amount of swelling is usually great and is accompanied with œdema about the eyelids, obliterating all facial expression and causing entire closure of the lids. Vesicles and bullæ also form on the cheeks. The inflammation may extend to the scalp or the neck, but the chin is rarely involved. The glands at the back of the neck are enlarged. In some forms the fever runs high, and there is usually considerable delirium. This may be due to reflex irritation of nerves or rarely to a suppurative meningitis, the result of a direct extension of suppuration in the orbit or to the meninges. Ordinarily, the delirium disappears when the fever subsides. There is more or less conjunctivitis, and some œdema in the orbital tissues. If suppuration should occur, blindness may result, a complication which is fortunately rare.

Erysipelas neonatorum occurs usually in epidemic form in hospitals. It begins as a slight inflammation about the umbilicus, but as it spreads to the genitals and thighs the constitutional disturbance is great and the prognosis grave. It may be complicated with phlebitis of the umbilical veins extending to the liver.

Erysipelas may involve the **mucous membranes**. In severe epidemics of erysipelatosus angina the tonsils are greatly inflamed and the tongue is often swollen. Diphtheritic or gangrenous inflammation of the fauces may also occur. These epidemics are rarely seen at the present time. Erysipelas may

extend to the glottis, and erysipelatous pneumonia, or pneumonia migrans, is described by some authors. The female genitals and the rectum may also be invaded by the disease.

The **curative influence** of erysipelas is shown not only in the effect produced by it on old ulcers, but even by the wound itself, which, when in the granulating stage, appears to heal more rapidly. Tumors also have sometimes disappeared during an attack. Lympho-sarcoma of the neck has been absorbed, the cells having undergone fatty degeneration. Both lupus and epithelial ulcers of the face have been known to break down, healthy granulations subsequently appearing which healed rapidly. Fehleisen took advantage of this circumstance to inoculate certain ulcers with cultures of the streptococci of erysipelas, and thus demonstrated the identity of the virus of the disease (p. 202).

The **prognosis** of erysipelas is usually favorable, as there is a tendency to self-limitation. The severity of the disease cannot, however, be predicted in any given case, but in small granulating wounds the disease is usually lighter than in large fresh wounds. Danger frequently arises from complications, as œdema of the glottis or secondary hemorrhage.

Treatment.—Attempts to restrain the infective process by antiseptic applications have thus far not been very successful. The apparent success of many drugs may be due to the spontaneous arrest of the process which so often occurs. Hot fomentations, containing corrosive sublimate of the strength of 1:10,000 or 1:15,000, or carbolic acid may be used; but care must be taken to avoid increased local irritation or poisoning by absorption of the drugs when a large surface is covered. An ointment of carbolic acid and vaseline, 1 to 100, may be brushed on the face with a soft brush or applied to other surfaces and protected with a thin layer of gutta-percha tissue or oiled paper. Zinc ointment is often useful. In phlegmonous erysipelas free incisions are indicated. The sloughs should be removed, and the pus-cavities must be disinfected as thoroughly as possible. Pressure with plasters or bandages in situations where they can be conveniently applied, has been advised to arrest the spread of the disease.

The constitutional treatment should always be supporting, and any depleting measures should be carefully avoided. The presence of delirium does not necessarily contraindicate the use of stimulants. Tincture of the chloride of iron has been recommended in large and frequent doses on account of its action upon the red blood-corpuscles, which are found crenated, and when placed under the microscope run together readily. This method was at one time received with great favor, but is less used at present. Quinine has also enjoyed a great popularity. Antipyretics as a rule have little effect upon the fever, and should be avoided, owing to the depressing influence upon the heart's action which many of them exert. Opium in some form and hypnotics are indispensable to allay the pain and procure sleep. Food should be carefully and frequently administered. When the blush has disappeared a complete change of bedding and clothing, with careful disinfection, may serve to protect the patient from a relapse due to a reinfection of the system.

CHAPTER XII.

TETANUS.

TETANUS is an infective disease, almost always originating from a wound. The central nervous system is the region chiefly affected by the bacterial poison which is the cause of the disease.

The **bacillus of tetanus** (Pl. II, Fig. 5) was discovered in 1885 by Nicolaier. It is a short rod with an enlargement at one end, due to sporulation, which gives it the characteristic drumstick shape. Although it is found in the dust of the street, it rarely finds an opportunity to grow in the living tissues, owing to its anaërobic properties; hence the rarity of the disease. It is found principally in the tissue near the wound, and is rarely, if ever, seen in the internal organs or blood. Several ptomaines have been extracted from the cultures of this bacillus, such as tetanine and tetano-toxine, and it is probable that most of the symptoms of irritation of the nervous system are due to the presence of these substances, as but few bacilli are found there.

Punctured wounds naturally offer the best opportunity for the growth of the anaërobic bacillus, and if such wounds are inflicted in dirty parts of the body, as the hands or feet, or foreign bodies covered with dust containing the bacilli are lodged in the tissues, the conditions favorable for infection are obtained. The state of the weather is said to have an influence upon the development of the disease. It has appeared in epidemic form with sudden changes in the weather after battles. It is also said to be much more common in tropical climates.

Tetanus is said to be **traumatic** or **idiopathic**. It is probable, however, that all cases of tetanus are traumatic, but that the wound is so slight in many cases as to escape notice. It has been known to follow such injuries as simple fracture, in which case internal infection probably occurs.

Acute tetanus most frequently makes its appearance at the end of the first week after the infliction of an injury, although this period varies considerably.

The first **symptom** complained of is a stiff neck, which the patient attributes to a slight cold. The muscles of the face and jaw are next involved, and the patient is unable to open his mouth, this symptom giving rise to the popular name "**lock-jaw.**" The muscles of the fauces and the pharynx are often in a state of spasm, rendering deglutition difficult. The muscles of the thorax and abdomen are next involved, and the muscles of the back are so painfully contracted that the head is thrown back, the spine is arched, and the body assumes the position known as **opisthotonos**. The lower extremities may also become rigid; the arms are, however, only partially affected. The muscular spasms, which are tonic, permit of little rest, and the sufferings of the patient are excessive and almost continuous. The expression of the face is totally changed by the contraction of the various muscles, which produces the characteristic **risus sardonicus**. The patient often experiences considerable difficulty in passing urine or in having a movement of the bowels. Any disturbing influence, especially noise, instantly evokes the muscular contractions and adds to the patient's sufferings. These have been known at times to be so severe as to produce rupture of a muscle or fracture of a bone. Such a condition permits of little sleep, and in the acute cases the patient rarely obtains any rest from the moment the disease makes its appearance. The temperature is usually not much elevated, but the skin is bathed in perspira-

tion. The pulse is weak and rapid, and as the disease progresses the exhaustion becomes marked, owing to loss of food and sleep. Sudden death often occurs in a paroxysm of dyspnea. The mind is usually clear to the last. Such an attack will run its course usually in two or three days.

In **chronic tetanus** the disease makes its appearance at a later date. The muscles are extensively involved, but there are periods of comparative relief, and as these intervals become gradually prolonged the patient has an opportunity to sleep. In the chronic form the disease may last several weeks. There is little change to be observed in the wound, although in some cases there are evidences of an infective inflammation.

Trismus is a name given to a milder form of the disease when the contractions are limited to the group of muscles about the neck and face.

Cephalic tetanus or **tetanus hydrophobicus** occurs after injuries in the region of distribution of the twelve cranial nerves. It is accompanied by paralysis of the facial nerve, usually on the side affected, and there is often spasm of the pharyngeal muscles, causing difficulty in swallowing. There is also trismus, and sometimes the muscles of the trunk are affected. It may be either acute or chronic. Many recoveries from the chronic form are reported.

Tetanus neonatorum or **trismus nascentium** is a general affection of the muscles in the newborn infant, beginning with trismus, and is due to an infection through the navel. It occurs occasionally in epidemic form in lying-in hospitals, and is a fatal disease.

Post-mortem examinations of cases of tetanus do not usually show any evident pathological changes. Some observers have found hyperemia of the medulla and cord, but others have detected no change. Brown-Séquard described an ascending neuritis, and Lockhart Clarke observed softening of portions of the gray substance of the cord.

The **diagnosis** of tetanus is usually not difficult in the acute cases, but in the milder forms it may be mistaken for other affections, as rheumatic inflammation of the jaws or hysterical contractions of the masseter muscles and excessive muscular spasm during the dressing of a sensitive wound. In strychnia-poisoning the muscles of the jaw are not rigid at first. Where the dose is small and repeated there will be intervals of rest. There is hyperesthesia of the retina and objects are colored green.

Tetany is a disease characterized by attacks during which tonic spasms of the various groups of muscles occur, principally of the upper extremities. According to Weiss, these attacks are due to an irritable condition of the gray matter of the medulla and spinal cord. It sometimes follows childbed and fevers and some mental shocks. It has also been frequently observed after operations for the removal of goitre. The spasms are tonic and give rise to great rigidity of the muscles. Between the attacks the patient appears well. The majority of cases get well without treatment. It occurs chiefly in young persons. Opisthotonos may occur, but trismus is absent. Pressure upon the nerve-trunk leading to the affected muscles will always bring on an attack. It is a rare disease in America.

Hydrophobia, which is popularly thought to resemble tetanus, is easily distinguished from it. The paroxysm of hydrophobia is not a true muscular spasm, and is limited to the muscles of respiration. The intervals of repose in the early stages and the mania in the later stages are also distinctive. One who has once seen the two affections would not be likely to mistake them a second time.

The **prognosis** of acute tetanus is of the gravest character. The only

hope in such cases is that the acute form may gradually assume a chronic type. According to Yandell's statistics, those patients who live beyond the fifth day are more likely to recover. Every day beyond this period improves the chances for recovery. Cases occurring after injury received in battle are much more fatal.

The prophylactic **treatment** consists in the thorough disinfection of all suspicious wounds. As soon as symptoms appear the patient should be isolated and kept in a darkened room, and extreme care should be taken to disturb him as little as possible. Any method of treatment which involves motion should therefore be avoided. Of all drugs, chloroform appears to have the most soothing effect upon the nervous system, and can be administered in small quantities by inhalation at frequent intervals. Chloral can also be given with the same end in view, and it may be combined with bromide of potassium. Inhalations of nitrite of amyl often act well, the relief persisting for some time after each inhalation. Morphine may be injected subcutaneously. Calabar bean has been used successfully. All of these drugs must be given in unusually large doses and for a considerable time, as a hesitating policy entails great suffering upon the patient. Retention of urine must be relieved by catheterization, and if the muscular spasm of the throat is excessive it may be necessary to administer nutrient enemata. There are few diseases where skilled nursing is of so much importance. Several authors have recently published cases of cure by injections of the tetanus antitoxin of Tizzoni and Cattani.

CHAPTER XIII.

SCURVY.

SCURVY is a constitutional disease traceable to the use of improper diet, defective chiefly in suitable vegetable food, and to imperfect hygienic surroundings. It is characterized by great disturbances of nutrition and a tendency to hemorrhage in the various tissues of the body.

History teems with accounts of diseases strongly resembling scurvy, but no reliable descriptions of any epidemic are to be found before the fifteenth century, when the great extension of navigation exposed the crews of vessels to prolonged privations such as had not before been experienced. During the present century it has been noticed chiefly in Arctic voyages and in many wars. The Allied armies suffered from this disease in the Crimea, and during the late Civil War the troops on both sides were affected. Perhaps the most striking epidemic of any occurred at Andersonville. During the siege of Paris in 1871 many cases of scurvy were discovered and carefully studied. It is rarely seen at the present time, and no opportunity has been obtained for studying it with the care which modern methods of investigation offer.

Scurvy has been supposed to be a contagious disease and also one of miasmatic origin, but it is now conclusively proved that imperfect nutrition is the most important factor in the **causation** of the disease. All are agreed that a deficiency in the variety of the diet is the principal cause of scurvy, but opinions differ widely as to the particular alimentary substance the absence of which brings out the symptoms of the disease. Some have supposed that the disorder was due to the lack of fresh vegetables. Others have thought that the excessive use of salt meats produced conditions favorable for the disease. Garrod's theory that a deficiency of easily assimilated potassium salts in the

food is one of the causes of scurvy has excited a good deal of attention. The most important factor, however, is certainly the absence of variety in diet. In certain instances the use of impure water has caused an outbreak of the disease, as was the case in Ranke's expedition into the interior of Australia. Unhealthy surroundings, as foul quarters in a ship; a bad state of the health, such as might result from great fatigue or dissipation; and mental depression, such as might occur among convicts,—are all predisposing causes.

Symptoms.—The early stages of the disease are marked by a condition of extreme lassitude. On slight exertion the heart's action becomes rapid and the respiration is increased in frequency. The patient complains of muscular pains in various portions of the body and is extremely sensitive to low temperatures. He is drowsy and apathetic and has an appearance of depression. There is no febrile disturbance and the pulse is slow and feeble. The skin is of a pale yellow hue, and is mottled here and there with brownish-colored spots. The epidermis is dry and brittle and there is considerable desquamation. The cutaneous follicles are unusually prominent, giving the appearance of "goose-flesh." This condition will last for several weeks before the symptoms distinctly characteristic of scurvy make their appearance. The gums then begin to be swollen and oedematous, and the mucous membrane of the mouth assumes a bluish tinge. The alveolar membrane is sensitive and bleeds easily, and the breath has a characteristic foul odor.

Petechiæ and numerous small extravasations are seen beneath the surface of the skin. They are at first observed about the roots of the hair, and appear as round bluish-red spots the size of a pin's head, which do not disappear on pressure. Later, some of the extravasations which take place are of considerable size and appear like bruises. Small vesicles form which later grow to large size and become occasionally the starting-points of ulcerations. The latter may, however, result from a septic infection and breaking down of the extravasations themselves. The ulcers vary in size, are covered with a brownish scab, and are surrounded by a violet discoloration of the skin. The granulations are unhealthy and give vent to a foul-smelling discharge. The muscles and the connective tissue are also the seat of hemorrhages, some of which break down and discharge an ichorous fluid. At other times they indicate their presence only by peculiar indurations to be felt in those tissues. Hemorrhages may occur also from the mucous and serous membranes. Inflammatory hemorrhagic effusions may take place in the periosteum. Swellings occur at the epiphyseal line, and the epiphyses may be separated from the shafts of the bones. The joints also may be involved. Even the eyes may be affected, and more or less disturbance of vision result (hemeralopia). The quantity of the urine is decreased, as also the urea and all the solid elements of urine. Fever is present during the height of the disease only when inflammatory complications prevail.

The *post-mortem changes* observed are the hemorrhagic effusions in various parts of the body and such inflammatory complications as may have occurred, especially croupous pneumonia and ulcerative endocarditis. Hemorrhagic infarctions are often found, the result of embolism derived from thrombi which form in the right auricle. Analyses of the blood have not as yet thrown much light upon the hemorrhagic tendency so conspicuous in this disease. Water is found in excess and an increased number of white corpuscles is observed. It is probable that a diminished power of resistance exists in the walls of the capillaries.

Diagnosis.—Scurvy may be distinguished from purpura by the cachexia and the persistent pains and the fetid breath accompanying the peculiar con-

dition of the gums. It may be distinguished in the same way from anemia, hemophilia, and leucocythemia.

The **prognosis** of the disease will depend greatly upon the stage at which the patient comes under treatment. Under favorable conditions improvement soon begins in most cases, but the duration of the convalescence is usually a prolonged one. If the use of the limbs is regained after a few days of treatment, the prospects of ultimate recovery are excellent. The recovery in uncomplicated cases is usually a complete one.

The **prophylactic treatment** consists in strict attention to the hygienic conditions, especially as to dryness and cleanliness on ships and in laying in a supply of live-stock. Among the antiscorbutics of repute at the present time may be enumerated eggs, milk, potatoes, beets, carrots, cabbages, onions, fruits, cocoanuts, pickles, cranberries, cider, lemonade, and lime-juice. The various meat extracts are also valuable and portable articles of food. Good drinking-water is also of the greatest importance as a prophylactic.

The curative treatment of the disease is almost exclusively dietetic. Nitrate of potassium is said to be of especial value. It may be used alone or mixed with vinegar (Wales). Antiseptic mouth-washes and lotions for the ulcers are also indicated. Any medication contemplated should be of a distinctly tonic character.

CHAPTER XIV.

TUBERCULOSIS AND SCROFULA.

SECTION I.—TUBERCULOSIS.

THE INOCULABILITY of tuberculous material was regarded as a possibility by Laennec and others, but Villemin in 1865 was the first to demonstrate the fact that the disease could be transmitted by inoculation to animals, and was therefore infectious like small-pox or syphilis. These views were confirmed in 1877 by Cohnheim, who successfully inoculated the anterior chamber of the eye in animals, and was able to observe through the transparent cornea, after a period of incubation, a development of numerous miliary tubercles in the iris.

The search for the bacillus was from this time pursued with energy, but the observations of Baumgarten gave the only reliable results. His discovery of the bacillus was almost simultaneous with that of Koch, who, however, in 1882 was the first to establish fully the identity of the organism and to cultivate it successfully.

The length of the **bacillus tuberculosis** is about one-half the diameter of a red blood-corpuscle. It is a thin rod, found single, in pairs, or in clusters. In tubercle in the human subject it is seen usually either single or in small numbers, and at times is quite difficult to demonstrate. It is found, however, in large numbers in experimental tuberculosis in certain stages of development, and therefore when it is not possible to discover bacilli with the microscope a diagnosis can be made by inoculation of a suspected tubercle into animals.

The **miliary tubercle** consists of a minute gray non-vascular nodule about the size of a mustard-seed. Under the microscope it is seen to contain a mass of leucocytes, near the centre of which are to be found a number of larger cells with one or more nuclei known as epithelioid cells and one or more

giant-cells. The appearance of such a cluster of cells is so characteristic that a tubercle can usually be recognized by the presence of the giant-cells without a demonstration of the bacilli, although these cells are also found in other growths besides tubercle (Pl. IV, Fig. 9). The structure of these giant-cells is peculiar, the nuclei being arranged in a somewhat radiating manner around the periphery of the cell, the center of which is made up of a granular protoplasm in a more or less advanced stage of degeneration. In studying experimentally the development of a tubercle it has been found that the first change consists in a division of the fixed cells of the part involved (by karyokinesis), by means of which process the epithelioid cells are formed. The giant-cell formation is due to the fact that the epithelioid cells do not show a tendency in the less active forms of tuberculosis to proliferate, but the division of the nuclei of certain cells continues, and the unusual cell-growth is thus produced. In acute miliary tuberculosis the cell-division is more active and giant-cells are less frequently found.

As the growth of tissue-cells begins to subside, the number of leucocytes which have wandered in from without begins to increase. The fine reticulum or network of fibers which supports the cells of the tubercle does not appear to be a new formation, but is merely the remains of the intercellular substance of the pre-existing tissue.

The bacilli are found either in the larger cells or between them; at times but one or two bacilli are found in the giant-cells. They are seen usually near the nuclei at the border of the cell. More rarely they are found in large numbers in the human subject. How they are brought to the part affected is not clear: it is thought by some that, not possessing any movements of their own, they are transported by the leucocytes, but this view would not accord with that first expressed (Baumgarten)—namely, that the leucocytes appear only at a later stage in the process of development. The bacilli are rarely found in the circulating blood.

Sections of tubercle are well shown by the double staining process, the fibers of the tissue being colored red by eosine, and the giant-cells being well brought out by the hematoxylin. In order to show the tubercle bacilli a special staining method is necessary. The staining fluid consists of the following ingredients: Saturated alcoholic solution of fuchsin, 10 parts; 5 per cent. aqueous solution of carbolic acid, 90 parts.

The section should be placed in a small quantity of this fluid in a watch-glass, and allowed to remain from one to twenty-four hours according to the degree of staining required. The section should then be decolorized with a 5 per cent. solution of sulphuric acid for a few seconds. If, when the specimen has been washed in alcohol 60 per cent., it is found not to be sufficiently decolorized, it should be replaced in the sulphuric acid. It should finally be dehydrated in absolute alcohol, cleared in oil of cloves, and mounted in Canada balsam.

Tubercle shows a tendency at an early period of its existence to undergo a **caseous degeneration**. This tendency is favored by the absence of blood-vessels, and the part which first succumbs to this process is the center of the tubercle, the portion farthest removed from the supply of nutriment. The change is principally due to a coagulation-necrosis, presumably caused by the action of the bacilli upon the cells. As a result of this change the mass presently assumes the appearance of a caseous nodule. If the progress of the disease is arrested at this point, the tubercle becomes enclosed in a fibrous layer the result of a reactive inflammation, and is said to be encapsuled, and the cells, having all undergone cheesy degeneration, are finally absorbed or the caseous

product is calcified. If, however, the process extends, the caseous nodule becomes larger, the necrosed material breaks up into a granular débris, and a fluid is produced which in appearance resembles true pus. These products of degeneration frequently contain the bacilli, and when inoculated into animals may reproduce the disease.

This *tuberculous pus* or puruloid material contains the broken-down masses of cells and a certain number of leucocytes and fragments of the coagulation-necrosis. The contents of cold abscesses arising from tuberculous processes are usually of this character, but occasionally the pyogenic organisms are found in this fluid, in which case true suppuration occurs. The tubercular pus is thin and of a peculiar white or chalk-like color: it contains lumps of cheesy matter the product of tubercular softening, and fragments of sloughs of the connective tissue. Crumbs of bone may occasionally be felt in it. If the tubercular nodule is on the surface of the skin or a membrane, such degenerative changes will lead to ulceration.

The local spreading of tubercular inflammation is caused by the growth of the bacilli, which involve new areas of tissue. Adjacent cavities or organs may thus be invaded. By the breaking down of bone-tissue the bacilli may gain an entrance into a joint, or the peritoneum may become infected from a tuberculosis of the intestine. When the bacilli enter the blood-vessels or lymphatics, they may be transported alone, or in the interior of small emboli, to a distant organ, and a general miliary tuberculosis may be thus produced.

Tuberculosis is probably the most common of all diseases, for it is estimated that 18 per cent. of all cases of death occur from this cause. According to Baumgarten, it arises more frequently by inheritance than in any other way; but, although the bacillus may undoubtedly be transmitted from parent to offspring, it is probable that only a predisposition to the disease is the more frequent result of heredity. The disease easily arises then in such predisposed persons when the bacillus gains an entrance to the body through the respiratory organs, whether inhaled with the air as dust arising from dried sputa and other excretions, or taken into the alimentary canal with food and penetrating the intestinal mucous membrane. It may also be introduced through wounds of the skin, chiefly of a trifling character, such as bruises or scratches. It is undoubtedly an infectious disease, and may be contracted by persons of healthy ancestry by continued exposure to its germs.

Tuberculosis of the skin includes a number of diseases which until recently have been regarded as different affections. The most frequent form is that known as *lupus*. This disease is now recognized as a lesion due to the presence of the bacillus of tuberculosis, although it is often extremely difficult to find the organism. The tendency of the disease is to remain local, but it may occasionally lead to a general tuberculosis. *Lupus vulgaris* is most frequently seen on the face, but other portions of the body may be the seat of the affection, particularly the extremities. It is characterized by a chronic inflammatory process, forming brown-red nodules with a tendency to ulceration and subsequent cicatrization. In this way a considerable area gradually may be involved. When the tendency to ulceration is excessive we have the form known as *lupus exedens*, although this name is often given erroneously to ulcerating forms of cancer of the face.

In other cases the amount of granulation-tissue may be a prominent feature, and then we have the form known as *lupus hypertrophicus*. When there is a tendency to the formation of cicatricial tissue the disease may produce extensive superficial alterations in the skin, and give rise to great deformity, the

whole surface of the face being occasionally involved. Patients with lupus not infrequently die of pulmonary tuberculosis.

The affection known to surgeons as *anatomical tubercle*, and frequently found on the fingers and hands of assistants in the autopsy and dissecting rooms, is now recognized as tubercular, and is regarded as almost identical with the variety known chiefly as *tuberculosis verrucosa cutis* or *verruca necrogenica*. It is characterized by plaques situated chiefly on the backs of the hands, arms, and fingers, looking at first sight like a cluster of inflamed warts. There are also erythematous patches and pustules.

Scrofuloderma is a name applied to certain tuberculous affections of the skin which formerly were not regarded as allied to lupus. It occurs as a more or less deep-seated, chronic inflammatory process in any part of the skin, preferably on the neck, body, or extremities, and shows a tendency to the formation of granulation-tissue, which breaks down and gives rise to sinuses or minute ulcerations. It is occasionally associated with disease of the lymphatic glands and bones. It is sometimes called scrofulous gumma, owing to its resemblance to syphilis.

Primary *tuberculosis of the panniculus adiposus* is observed, particularly in children, in the form of flat subcutaneous nodules which gradually soften and break down and discharge. In some cases they may burrow extensively without coming to the surface. Tubercular abscesses of the deeper connective tissue are, however, usually secondary to some affection of the bones or joints or lymphatic glands. The larger abscesses, generally known as **cold abscesses**, originate most frequently from tuberculous disease of the bones. Such cavities, when opened, present a characteristic appearance. The walls are covered with a membrane of a grayish-yellow or grayish-red color, which is loosely attached, and can readily be removed with the finger or sharp spoon in large fragments. It consists of a very soft and slimy material, which contains great numbers of miliary tubercles closely packed together and imbedded in masses of fibrin. When scraped away healthy tissue is exposed. At one spot the persistence of a small islet of granulations indicates the opening of a fistulous track which leads to diseased bone. Occasionally no such fistula can be found. This is the case in the so-called peri- or para-articular abscess when the septic infection of the connective tissue is transmitted from a diseased bone or joint through the lymphatics. Such abscesses, although at first not communicating with the affected joint, may later establish an opening into it. Fistulæ leading to tubercular abscesses are also lined with a tuberculous membrane. The pus of these abscesses may contain a few leucocytes, but consists chiefly of the products of caseous degeneration. The presence of the bacilli of tuberculosis, although not easily determined with the microscope, is often demonstrated by experimental inoculation in guinea-pigs. In the typical cold abscess pyogenic cocci are not usually found under the microscope, nor can they be obtained from cultures of this pus. The absence of fever in cases where these large abscesses are found is thus explained, and the constitutional disturbance which frequently follows the opening of a cold abscess is undoubtedly due to a subsequent additional infection with the pyogenic cocci.

Adjacent *muscles* are rarely infected by tubercular abscess: it is now well understood that striped muscular fiber is not liable to tuberculous disease.

Tuberculosis of the *mucous membranes* may follow or accompany lupus of the skin. A direct extension may take place from the alæ of the nose or from the lips to the nostrils, gums, or pharynx.

Tuberculosis of the *tongue* is a comparatively rare affection, and is liable to be mistaken for cancer or syphilis. It appears as a chronic inflammatory pro-

cess which produces an infiltration extending to the deeper muscular tissue. On the surface ulceration may take place. It may be associated with tuberculosis elsewhere, and the presence of pulmonary signs or fistula in ano would serve as aids to diagnosis. The prognosis will depend largely upon the general condition of the patient.

Lupus of the *velum*, *tonsils*, and *pharynx* is often found associated with lupus of the skin, and, according to Lennox Browne, is more likely to be seen in skin than in throat clinics. It appears in the form of numerous superficial ulcerations surrounded by inflamed and thickened borders, which show a tendency to become confluent. There is less loss of substance than in syphilitic lesions of these parts, as the ulcer tends to cicatrize. The adjacent mucous membrane is often found studded with miliary nodules, which run together, break down, and form new ulcerations. The miliary tubercles are situated immediately beneath the epithelial layer, and may also involve the intermuscular and connective tissue. The giant-cells are numerous and well developed; the number of bacilli is, however, usually small. Many of the patients who are the subjects of these affections succumb to pulmonary tuberculosis.

Tuberculosis of the throat or lungs may give rise to *tubercular disease of the intestinal canal*. As a result of such infection ulcers may form in the neighborhood of the cæcum and appendix, and may perforate the bowel and give rise to a tubercular abscess. Tubercular inflammation of the large intestine has been known to give rise to so much obstruction as to necessitate laparotomy, which has been successfully performed. The development of tubercular peritonitis from this source is supposed to be much less common than from the Fallopian tubes.

Most cases of *fistula in ano* are tuberculous. They are characterized by the formation of fungous granulations and a tendency to burrow beneath the skin and mucous membrane. In many of these cases symptoms of pulmonary disease are also present, and the prognosis is then exceedingly unfavorable.

All portions of the *genito-urinary tract* appear to be affected by tuberculosis. Lupus is found occasionally on the labia majora. Cornil has found the bacilli in ulcerations of the vagina adjoining a vesico-vaginal fistula. In six autopsies of cases of tuberculosis of the uterus he found in three a number of bacilli. Tubercular infection of the Fallopian tubes often supervenes upon a chronic catarrhal salpingitis in cases of tubercular disease of other portions of the genital mucous membrane. It is possible that infection of the female genital organs may result from coitus, as the bacilli of tuberculosis have been found in the semen of tuberculous men even in cases where the genital organs are not the seat of tuberculous disease. Tuberculous peritonitis not infrequently accompanies tuberculous pyosalpinx.

Tuberculosis of the *mamma* is rare. Tuberculous ulcerations or sinuses may occasionally be seen about the nipple, and yield readily to treatment. Several cases are reported by Cornil where miliary tubercles containing giant-cells and bacilli were found in the ducts of the gland. Tillmans recommends, in every case of tuberculosis of the mamma, extirpation of the breast and the lymphatic glands.

Tuberculosis of the *male genital organs* has usually an unfavorable prognosis. Tuberculosis of the *testicle* occurs most frequently in early adult life. Many cases of cure occur without operative interference, although there is danger that the disease may propagate itself along the course of the vas deferens to the vesiculæ seminales, the prostate, and the bladder if the testicle

is not removed. Tubercles are found in the urethra, in the membranous portion chiefly, but the disease is more frequently described as existing in the bladder. It may at times be quite extensive and involve the kidneys. It is one of the most difficult forms of the affection to deal with, and early diagnosis by detection of bacilli in the urine is therefore important.

The tubercular affections of *bones* are found most frequently in the vascular spongy tissue of the epiphyseal ends of the long bones. Tuberculosis of the shaft of the long bones is comparatively rare. The disease is found in the short spongy bones, as the bodies of the *vertebræ* and the bones of the tarsus and carpus. It is also seen occasionally in the flat bones, as those of the skull and the pelvis, the orbital portion of the superior maxilla, and the ribs. In the epiphysis the tuberculous nodule is usually formed some little distance from the cartilage. On section of the bone one sees, in the beginning of the disease, a yellowish-white or pure yellow well-defined mass lying in the spongy tissue, which even with low powers can be seen to be made up of miliary tubercles, some of them already in a state of cheesy degeneration. As this nodule grows in size it becomes softened, and finally forms a cavity containing a more or less softened material mingled with minute fragments of bone; or the degenerated bone becomes necrosed in a mass and forms a sequestrum. This is generally of a roundish form and frequently as large as a walnut, and is surrounded by a layer of granulation-tissue which is also infected with tubercle bacilli. More rarely the tuberculous nodule may break down and form a small abscess. Such pus-cavities are most often seen in the extremities of the tibiæ. Occasionally the nodule may remain for a long time unaltered, and is then surrounded by a dense capsule. Sclerosis or eburnation of the surrounding bone may occur under these circumstances. The bacilli reach the epiphysis usually through the circulation. They are most frequently conveyed there as single organisms floating in the blood, but they may be transmitted in emboli, possibly from a tubercular mass in the bronchial glands. If such an embolus should plug a terminal arteriole, an infarction of the bony tissue may result, forming a wedge-shaped sequestrum with its base directed toward the joint and the apex pointing toward the diaphysis. These wedge-shaped tubercular infarctions have been produced experimentally in animals by injecting tuberculous pus into the tibial artery. It is possible that a growth of granulations may invade the tubercular mass, and that complete absorption may take place; and the part may be thus restored to its normal condition. Even a tubercular sequestrum may be disposed of in this way under favorable conditions. Usually, however, the nodule softens and the tubercular pus breaks into the joint or into the adjacent connective tissue. When the joint is involved, tubercular infection of its surface will occur and disorganization will probably take place. When the pus discharges through the periosteum, a cold abscess will form which may burrow extensively and finally break externally.

Tuberculous *osteomyelitis* of the shaft of the long bones occurs chiefly in the phalanges of the hands and feet. The disease appears first in the marrow, which with the cortical bone is changed into granulation-tissue: at the same time the periosteum is stimulated into a new bone-formation, which in its turn becomes involved. In consequence of these progressive changes the bone is much distended in the middle of its shaft, the so-called *spina ventosa*. The disease may undergo spontaneous cure or suppuration may take place. Considerable deformity may be caused by atrophy of the affected bones in early life.

Tuberculosis is also frequently observed in the short spongy bones, particularly in the bodies of the *vertebræ*, giving rise to *Pott's disease*, and in the bones of the carpus and tarsus. The changes produced in bone-tissue by

the bacillus of tuberculosis is that known hitherto as caries; that is, an absorption of the bony tissue, giving it a worm-eaten appearance. Necrosis is more frequently the result of acute inflammation produced by the presence of the pyogenic cocci, but, as we have seen, it may occasionally be due to the action of the bacilli of tuberculosis.

Tuberculosis of the *joints* (known often as white swelling, tumor albus, hip disease, ankle disease, etc.) usually results from infection by the opening of a primary nodule from the bone into the joint. A primary tuberculosis of the synovial membrane, however, may also occur. As the consequence of infiltration with miliary tubercles we find a thickening of the membrane with formation of granulation-tissue which may not be accompanied by any collection of fluid in the joint. At other times there is considerable turbid or bloody fluid, or suppuration may take place and the joint contain the characteristic thin and pale tubercular pus. When the tendency to the formation of granulation-tissue is excessive, the condition known as *caries sicca* exists. Little or no pus is formed, but there is extensive loss of bone as the result of caries. Occasionally circumscribed tubercular nodules form on the synovial membrane and project into the joints as small pedunculated tumors, consisting of fibrous tissue, but containing a softened tuberculous mass in the interior. In the serous form of tuberculous synovitis numerous "*rice bodies*" or "*melon-seed*" bodies are seen in some cases, either free in the joint or attached to the capsule by a pedicle. They are composed of concentric layers of fibrin, a substance which is so often associated with the formation of tubercles.

As the disease progresses the articular cartilage is attacked by the granulation-tissue in the joint, and ulceration takes place, or granulation-tissue may form in the epiphyses and perforate the cartilage from beneath. In cases of long standing the disease spreads from the capsule to the surrounding tissues, and the connective tissue, the tendons, and even the muscles, become involved in a gelatinous degeneration. This peculiar change is supposed by some to be a saturation of the diseased tissue with a fluid of a mucous or synovial character. Under favorable conditions a more or less complete restoration of the joint-cavity may take place, but when the disease is once well developed the best that can be hoped for is a fibrous or bony ankylosis. If suppuration takes place, the abscess may open externally, and fistulæ communicating with the joint may be established. In long-standing cases of joint-suppuratoin amyloid changes are found in the internal organs.

Tuberculosis of the *tendon sheaths* is usually secondary to bone or joint disease, but it occurs occasionally as a primary affection. A thickening of the tendon sheaths takes place and develops into a cylindrical doughy swelling, which is usually not painful. Rice or melon-seed bodies often form. A portion of the new tissue softens down and fistulous openings occur. If the sheath is laid open by a longitudinal incision, a mass of gelatinous tissue is found which can easily be stripped off. Such an operation may result in cure.

Tuberculosis of the *lymphatic glands* is a very common affection. Enlarged glands may be found at the autopsies of children dying of almost any disease, and on examination prove to be the seat of tubercle. The disease may occur in the glands secondarily to the involvement of some adjacent organ, as in the bronchial or mesenteric glands from pulmonary or intestinal tuberculosis. In the glands of the neck, which are by far most frequently affected, the disease often appears to occur primarily, but is in reality usually secondary to a catarrh of a mucous membrane or to a cutaneous eczema. The bacilli are few in number except in the glands nearest to the primary focus, and in many glands they cannot be found. In abscesses of lymphatic glands they may be found in the

tuberculous membrane which lines their walls. In the bronchial glands the bacilli are often seen in the capsule and the periglandular tissue. As a result of caseous degeneration and infection with pus cocci abscesses may form, and a spontaneous cure may be rarely effected. Where an extensive invasion of the lymphatic system takes place the bacilli eventually reach the circulation, and acute miliary tuberculosis may result; but this is brought about more frequently by the entrance of the bacilli into the veins and their dispersion in emboli to different parts of the body.

The **diagnosis** of tuberculosis can usually be established by the clinical symptoms and history of the case, but in doubtful cases a microscopic examination may reveal the presence of the bacilli. This can be done by an examination of the sputa or urine. (See Surgical Bacteriology.) If the case is one of doubtful lupus, a fragment can be punched out with the Mixter exploring canula, and sections can thus be obtained for microscopical study. In those cases in which the bacilli cannot be found recourse must be had to experimental inoculation. A fragment of the suspected tissue can be implanted into the subcutaneous connective tissue of the groin of a guinea-pig, and if the specimen is tuberculous a miliary tuberculosis will be produced in from five to six weeks.

The **prognosis** of the disease depends greatly upon its locality. In tuberculosis of the skin and superficial tissues it is more favorable than that of internal organs. In children the prognosis is generally more favorable than in adults. Any tuberculous nodule is always a source of danger, and should not be allowed to remain if it can be removed. There is always the possibility of recurrence even after operation.

The operative **treatment** consists either in complete removal of the diseased tissue by incisions carried through the surrounding healthy tissue or in a thorough curetting, followed by free irrigation with iodine-water, packing with iodoform, or occasionally by the actual cautery. In laying open healthy tissues the possibility of an infection of the system with bacilli should not be forgotten; hence thorough removal or no operation is the rule. The special methods of dealing with the local conditions will be considered in their appropriate places. The general treatment of the disease is of the greatest importance. This consists chiefly in the selection of a suitable nourishing diet and an appropriate climate. When change of residence cannot be effected the patient should be kept as much as possible in the open air. Among the most valuable of internal remedies are cod-liver oil, the hypophosphites, and alcohol. Koch's remedy, which is at present attracting so much attention, is prepared as follows:

Tuberculin, or *paratoloid*, is obtained from a pure culture in nutrient bouillon of the bacillus of tuberculosis by extraction with 50 to 60 per cent. of pure glycerin. As dispensed for use, it is put up in small vials holding about five cubic centimeters, and consists of a viscid dark-brown fluid of an alkaline reaction and somewhat bitter taste. The fluid as at present prepared does not consist entirely of the active principle, of which there is estimated to be but about 1 per cent. This is not one of the ordinary ptomaines, for the reason that it is not decomposed by any ordinary degree of heat, as are these latter. The material may be subjected to a sufficient temperature for complete sterilization without affecting its potency. The activity is supposed to be due to a compound belonging to the class of toxalbumins which have come into prominence and which are not changed by heat. It is precipitated by alcohol as a heavy flocculent white precipitate, which disappears at once upon the dilution of the alcohol.

The original material is prepared for use by the addition either of water or, if one desires to keep the dilution for some time, of a 0.5 per cent. of carbolic acid. The dilution should be made with the greatest care and with thoroughly sterilized pipettes, solutions, etc. The usual proportion is 1 per cent., so that in a syringe divided into tenths of a cubic centimeter each division will contain one milligram of the original material, this being the average dose at the beginning of the treatment. After the dilutions have been opened and their use is over for the day, they may be sufficiently sterilized by placing them in a sterilizer for five minutes after the steam has begun to pass. With this precaution they may be used for a period of at least ten days.

Human beings are much more susceptible to the action of the material than are the lower animals, especially guinea-pigs. In the latter there has been injected as much as four centigrams of the original material with no apparent effect.

The syringe used for the subcutaneous injections is pistonless, and its contents are expelled by a rubber ball. It was designed by Koch for the purpose of obtaining an instrument that could be easily sterilized. The point usually selected for injection is the skin of the back beneath the scapula.

The mode of action of this remedy is to produce an inflammation of varying degrees of severity in the tissues which are the seat of the tubercle. It is analogous to the effect produced by an acute inflammation upon a chronic one. The surrounding connective tissue is inflamed, but the miliary tubercles remain unchanged beyond a certain diminution in size. In ulcerating forms of the disease the tuberculous tissues are more readily separated and thrown off. The material is injected subcutaneously, either with the Koch syringe or the ordinary hypodermatic syringe. The smallest dose is one milligram, but ten milligrams are often given after the treatment has been continued for some time; and this is occasionally increased later to five hundred milligrams. At the conclusion of the treatment as large a dose as one gram has been given by Bergmann.

Thus far, a primary improvement has been noticed, but the disease usually returns after a cessation of the treatment. It has been found by Bergmann in cases of lupus that a preliminary curetting and cauterization of the nodules, followed by a course of injections of tuberculin, offers the most favorable prospects of success. But very few cases of permanent cure by this method have as yet been reported.

Cheyne has obtained more satisfactory results by substituting for the intermittent dosage of Koch a continuous dosage, which consists in giving the injections two or three times a day, and increasing the dose, sometimes slowly, sometimes rapidly, until occasionally as much as three decigrams were given three times a day. Of 9 cases so treated, 6 improved to such an extent that no evidence of disease was seen some weeks after treatment. Treatment should be continued for a long period. In conjunction with other treatment, he found it useful in lupus and in cases of bone and joint disease after operation when healing had not taken place. He found by experiment that tuberculin predisposes the tissues to fresh infections. In guinea-pigs which had been previously treated with tuberculin the disease appeared earlier and progressed more rapidly than in others.

He also treated a number of patients with the *derivatives of tuberculin* obtained by Dr. William Hunter. According to the latter observer, tuberculin owes its activity not to one principle, but to at least three, and probably more, different substances. By taking advantage of the action of absolute alcohol on tuberculin he obtained by precipitation a fluid consisting of proteid materials and a small quantity of salts. This caused no pyrexia when injected, but pro-

duced the depressing effects of tuberculin and the local inflammatory reaction. The residue from the filtrate contained the salts in excess and a small quantity of proteid materials. This fluid when injected caused fever, but produced no local inflammation. The local disease, however, appeared to improve under its use. He also obtained from the residue of the filtrate, by a process of dialysis, a substance which produced very distinct local improvement, but was unaccompanied by fever or local inflammatory reaction. Still a fourth material was obtained by precipitating more thoroughly the proteid substances of tuberculin ammonium sulphate being employed instead of alcohol. The action of the substance thus obtained was very much like the one last mentioned, but a little more rapid.

A somewhat limited experience with the last two substances in cases of human tuberculosis showed that the disagreeable features were avoided, but that the remedial effects were nevertheless obtained.

SECTION II.—SCROFULA.

SCROFULA (from *scrofa sus*, a swine) is a name formerly applied to all tuberculous affections except those of the lungs. At the present time the term is synonymous with tuberculosis of the glands, joints, or bones. It is still, however, an open question in the minds of some pathologists whether the name should not be reserved for a certain class of cases clinically resembling tuberculosis, but which are caused by the presence of some other form of micro-organism than the bacillus of tuberculosis. By others there is supposed to be a certain type of constitution which is peculiarly susceptible to external irritants of various kinds which may produce inflammation of the skin, mucous membranes, or lymphatic glands. Such individuals are considered equally susceptible to tuberculosis.

The observations of several observers have given some support to this theory. Charrin and Roger examined a guinea-pig which had died of a disease which resembled tuberculosis, but were unable to find the characteristic bacilli. Cultures, however, were obtained which were found to consist of bacilli much smaller than those of tuberculosis. When other animals were inoculated from these cultures a similar disease was produced. Similar observations have been made by Eberth and Pfeiffer. Babes describes a case of acute bronchitis with miliary tubercles of the lungs in which oval and fusiform bacteria 0.8 micromillimeters in length were found in the tubercles. Observations of this kind have given rise to the name "pseudo-tuberculosis," and it does not seem improbable that certain affections of this class may be due to other organisms than the bacilli of tuberculosis.

Two types of the affection are usually described—the torpid and the erethistic. The *torpid* form is the most characteristic. Such children have light or reddish hair, a sallow and pasty complexion, puffy cheeks, and protruding lips. The eyelids and conjunctivæ are often the seat of a chronic inflammation. Catarrhal affections of the nose and ear often exist, the skin is eczematous, and the cervical glands are enlarged. The general appearance of such a patient suggests the origin of the name "scrofula." In the *erethistic* form there is less tendency to glandular enlargement. The individuals are dark-colored, of a nervous temperament, and are subject to catarrhal affections. Undoubtedly there are certain types of children of delicate constitutions who need an unusual amount of care; and, although the above description savors somewhat of an antiquated pathology, it is well to remember that not all enlarged glands or swollen joints or inflamed bones are tuberculous. Such children should be

placed under the most favorable hygienic conditions, and exposures and fatigues of all kinds should be avoided. They should not be subjected to too rigorous a school discipline. Adults should seek the most favoring climates. Cod-liver oil and iron are the most useful tonics for these cases when medical treatment is indicated.

CHAPTER XV.

RHACHITIS.

THE term *rhachitis* is derived from *ῥάχις*, the spine. The English name *rickets* is, however, more commonly used. It is a general disturbance of the nutrition of the body in infancy and childhood, and consists principally in an insufficient deposit of lime-salts and in absorption of already-formed bone.

Etiology.—It is a disease seen chiefly among the poor in large cities, less frequently in the country. It is much more common and severe in Europe than in America. In America the disease is neither very prevalent nor very severe, and except in colored children or in Italians and Portuguese very great deformity is rare (Bradford). Bad hygienic influences, such as poor ventilation, damp dwellings, and crowded rooms, are frequent causes of the disease, but the most important cause of all is improper feeding. The substitution of patent foods for the mother's breast-milk is said to favor its development. In menageries, where animals live under highly artificial conditions, the disease is frequently observed. In congenital syphilis changes in the bones closely resembling those of rickets are occasionally seen. The disease begins in the first or second year of life, exceptionally after the fifth or sixth. It is not often seen in newborn infants, but rhachitic changes are occasionally found in the bones during fetal life.

The **pathological changes** are due to the formation of incompletely calcified bone. "Osteoid tissue" persists, therefore, much longer than usual. At the epiphyses there is an absence of the line of calcification; there is a great increase in size of the zone of cartilage-growth, and the medullary tissue grows into the cartilage area in the most irregular manner. The cortical portion of the bone becomes porous, and the trabeculae of the spongy bone become thinner or disappear entirely. After the disease has run its course calcification may take place on an increased scale, and sclerosis of the bone may occur. Rhachitic bones are frequently so soft that they can be cut with the knife, and as a result of this change great deformity often occurs. In older children such changes are seen in the bones of the thorax, spine, and extremities; less frequently in the skull. The ligaments are relaxed and movements of the joints are often painful. The promontory of the sacrum is depressed, and the pelvis thus greatly narrowed. Curvatures of the spine, as *scoliosis* or lateral deviation, *kyphosis* or curvature with convexity backward, and *lordosis* or curvature with convexity forward, are also observed. In the skull the bones are often unnaturally thin and crackle under pressure like parchment. This condition is known as *craniotabes*. Dentition is often delayed, and during convalescence progresses with great rapidity. It is always irregular.

The brain may be hypertrophied, and sometimes is sclerosed; hydrocephalus may also occur. The bronchial tubes are filled with mucus, and emphysema of the lungs is occasionally found. Evidences of intestinal catarrh are seen. The spleen is often enlarged.

Among the early **symptoms** is restlessness at night, with a tendency to profuse perspiration especially about the head; the bowels are constipated and the belly becomes distended. The urine is large in amount and loaded with phosphates. In the bones the earliest changes are seen at the epiphyses, which become thickened chiefly at the end of the radius, and in the ribs, where the row of beaded enlargements is quite characteristic. With the softening of the bones deformities of the spine and extremities begin. The head is increased in size, particularly the forehead and the frontal eminences. The distortion of the ribs gives rise to the characteristic pigeon-breasted deformity. Catarrhal affections, as bronchitis, and even pneumonia, may occur as complications, as also laryngismus stridulus. Among important diagnostic symptoms are delayed dentition and delayed closure of the anterior fontanel. A search for the epiphyseal enlargements will usually settle the diagnosis. Rickety children are often stunted in stature.

The **prognosis** is usually favorable. Deformity disappears in 90 per cent. of the cases. A few cases terminate fatally from complications, such as broncho-pneumonia.

In the **treatment** of rickets careful regulation of the diet is of the utmost importance. Fresh food should be given in preference to prepared foods; fresh milk properly diluted for infants, and meat-juice or raw beef for older children. Fresh air and light in the nursery should be obtained if possible. Salt-water bathing is highly recommended. Cod-liver oil is considered the most valuable of drugs. Phosphorus is also a favorite remedy; syrup of the iodide of iron is perhaps to be preferred. Lacto-phosphate of lime is given on theoretical grounds chiefly, but is a good tonic for children. Those modern inventions, "sea-shore homes" and "day nurseries," are particularly adapted for the treatment of this disease. The surgical operations for deformities of bones are described elsewhere.

CHAPTER XVI.

CONTUSIONS AND WOUNDS.

SECTION I.—CONTUSIONS.

AN injury produced by a blunt body in which tissue-elements are more or less rent asunder, but in which there is no gross or manifest external breach of tissue, constitutes a contusion. In a simple contusion or bruise the area of damage is limited by the area of impact of the bruising body, but the amount of damage may be of any grade, from the imperceptible molecular division of a slight bruise to the pulpification of large masses of tissue. The element of contusion is present as a complication of most wounds, and in many constitutes a grave and most important factor. The distinction between a contusion and wound is therefore one of degree and not of kind. A contusion should be defined more properly as a hidden wound, the firmer tissues of the skin being able to resist the rending effect of the blow, which produces its greater effect upon softer tissues underneath. Whether an injury shall be defined as a contusion or a wound depends also upon the character of the injured structures and the nature of the tissues which lie underneath the surface. Thus a hard, bony surface, so related to the tissues on which a blow is struck that they are forced against it by the bruising body, will necessarily aggravate an injury, and much

more readily cause an absolute destruction of all the tissues, including the skin, and so produce a wound, than if a thick cushion of soft tissue alone is involved. The results of blows over the shin are examples of the first, while those upon the surface of the abdomen or upon the fleshy masses of the nates or the thighs are examples of the second.

Pathology.—The pathology of a contusion is that of a subcutaneous wound. The more delicate and easily-torn tissues suffer first and most extensively; ruptured blood-vessels give rise to more or less hemorrhage; injured nerve-fibrils are the sources of pain; functional disability follows according to the extent and character of the tissues injured; local swelling, both from hemorrhage and from serous effusion, quickly ensues. When the effused blood shows itself as a somewhat diffused subcutaneous discoloration, an *ecchymosis* is said to be present; when, however, it is collected in a more or less well-defined cavity, so as to constitute a blood-tumor, it is known as a *hematoma*. When blood-vessels of some size are involved in a contusion, special conditions of hemorrhage may arise; thus they may be either ruptured outright or their walls so bruised that they subsequently slough, and so occasion a later hemorrhage. The hemorrhage from the smaller vessels is usually soon controlled after moderate escape of blood by the reactive pressure of the surrounding engorged tissues. The force of the blood-current in large veins and in most arteries is likely to be such as to cause a considerable loss of blood, especially when it escapes into any of the great cavities of the body or when the locality involved is one in which there is present much loose connective tissue. Contusions of nerves may produce more or less paralysis of the regions supplied by them. A progressive degeneration of a nerve may result from the changes produced in it by a violent contusion. The effects of contusions of muscles depend upon the extent of the damage done; local soreness and pain upon movement attend less severe injuries; rapid recovery under rest and proper treatment is to be expected in such instances; from even quite extensive lacerations ultimate recovery with full functional power often takes place. In less favorable cases, however, atrophy, contracture, and permanent loss of power may result. The contusions of bone when short of absolute fracture are usually rapidly recovered from, but may develop into acute or chronic inflammatory conditions or determine caries or necrosis, or even the development of malignant changes.

Diagnosis.—The symptoms which indicate the occurrence of a contusion are easily recognized. The part is tender and quickly becomes somewhat swollen, with some elevation of temperature. In simple and superficial contusions discoloration of the skin soon declares itself as the result of the subcutaneous hemorrhage. In cases where deeper structures are especially contused the appearance of the external discoloration may be delayed for some days, owing to the slowness with which the effused blood finds its way to the surface. Loss of function may be present, dependent upon the character of the tissues injured and the extent of the injury inflicted. The amount of pain in the part may vary. At first there is numbness, followed quickly by severe acute pain, which gradually subsides with the lapse of time. Shock is almost always present to some extent. Contusions of moderate severity produce a degree of shock characterized by momentary stunning; others of greater severity may produce faintness or total loss of consciousness for a variable period; while in the more severe cases, as in contusions of the abdomen, immediate death may ensue.

Treatment.—For the general shock and the local pain the treatment required for such conditions accompanying any injury is indicated. For the contusion itself the first thing to be secured is rest to the injured part.

This is especially important when the contusion is severe and the injuries to deeper structures are extensive. For securing rest, if voluntary immobilization is not sufficient, the use of apparatus of some kind may be required. Bandages, slings, splints, a recumbent position in bed, all may have their use. By rest local irritation is diminished, hemorrhage and inflammatory effusions are restricted, the absorption of effused fluids and of necrotic tissue is favored, and the normal repair of the injured tissue is fostered. Of all means for treating these injuries, rest is the one of primary and greatest importance.

Next, hemorrhage and serous effusion may require attention. Equable, elastic, and firm compression is to be recommended for their control. Compresses of cotton wool secured by proper bandages are especially serviceable for this purpose. A simple flannel bandage alone will often be of great service. When, for any cause, the use of compresses and bandages is inconvenient or undesirable, some advantage may be obtained from the application of cold, by ice-bags, evaporating lotions, or affusions of cold water. In the more severe forms of contusion cold is to be used with caution, since by its continued use the vitality of the parts is depressed, and tissues which under more stimulating treatment might be preserved from necrosis and regain their normal condition may be precipitated into absolute death. In the slighter and more superficial forms of contusions evaporating lotions are frequently both convenient and efficient. As an example of such a lotion a solution of chloride of ammonium and alcohol (gr. v @ f ʒj) is to be recommended. Tincture of camphor, tincture of arnica, tincture of witch-hazel, all favorite popular applications for contusions, are of use, but depend for their efficiency chiefly upon the alcohol which they contain.

In cases in which much bruising and disorganization of tissues are present great care must be taken to avoid everything which may still further depress the vitality of the part. The indications are, then, to support and stimulate. In addition to the rest already recommended, a moderate amount of heat will be of use; hot-water bags, the hot-water coil, masses of cotton wool, or flannel previously heated, may be found useful. In the later history of many contusions massage and stimulating liniments are of value. They promote the activity of circulation in the part, break up and diffuse among the tissues blood-clots and serous accumulations, and hasten their absorption; they promote the nutrition of the injured tissues, break up adhesions, and expedite the return of the normal functional activity of the contused parts. Blood-extravasations as a rule should be left to the natural processes of absorption for their removal.

Blood-effusions widely dispersed along connective-tissue planes, infiltrating tissues already lowered in their vitality by a contusion, present conditions eminently favorable for the development of widespread and disastrous septic infection, for which reason an attempt to evacuate a hematoma by incision under ordinary circumstances is always to be deprecated. When, however, continuous subcutaneous hemorrhage is present, showing the existence of a wound of a vessel of importance, it is imperative to make a free incision, so as fully to expose the wounded vessel, and to apply a ligature to it. In such cases the incisions through the external parts should be very free, and all recesses into which the effused blood has found its way should if possible be opened up. All clots should be turned out, and the most perfect disinfection and drainage of the infiltrated areas provided for. Circumscribed blood-tumors may sometimes be relieved by aspiration. After the lapse of two or three weeks from the time of the original injury any persisting blood-tumor may be more freely laid open and its contents evacuated; by this time it will

be surrounded by a layer of condensed connective tissue reinforced by inflammatory exudation; the surrounding tissues will have recovered from the state of depression immediately following the injury; and as the result of these conditions the danger of septic infection will have greatly diminished.

Severe inflammatory reaction following contusion must be treated upon general surgical principles, including rest, elevation of the parts, evaporating lotions, together with such constitutional measures as may be required for relieving pain, reducing temperature, and lessening the intensity of the general febrile reaction. If suppuration occurs, adequate incisions must be made for the evacuation of the pus; if local gangrene threatens, stimulating applications are first required, as dry heat or stimulating liniments, until the line of demarcation of the slough is distinctly formed. Fomentations should now be used, composed of compresses wet with some antiseptic solution and covered with rubber dam or oil silk, to hasten the separation of the slough. If phlegmonous inflammation advances into adjacent parts, free incision into the inflamed tissues, with abundant antiseptic irrigation and iodoform tampons, should be used.

SECTION II.—WOUNDS.

A WOUND is a solution of continuity of any tissue, produced either directly or indirectly by sudden mechanical force. The occurrence of a solution of continuity in any of the solid tissues of the body may be due to slowly-acting causes, as the gradual waste of atrophy, or the more active disintegration of ulceration; but a breach of tissue thus affected would not be a wound. There is involved in the idea of a wound the action of a force outside of the tissue itself, which by mechanical violence has rent or divided its substance. The term "wound," therefore, is susceptible of a very wide range of application. Contusions, sprains, fractures, subcutaneous as well as cutaneous breaches of tissue, are included in the term. In all essential particulars they are identical accidents, involving the same methods of repair and subject to the same principles of treatment, the apparent differences depending upon accidental differences of structure, function, nutrition, relation to other parts, extent of traumatism suffered and of exposure to influences from without. In the present chapter the wounds of bones will not be considered.

Classification.—Wounds may be divided primarily into the two great classes of *subcutaneous* and *open* wounds. Subcutaneous wounds include all which are unaccompanied by breach of the skin. Protected by the unbroken skin from external irritation and infection, their repair is usually rapid and undisturbed by untoward irritations. The preceding paragraphs devoted to the consideration of contusions are descriptive of the greater number of subcutaneous wounds. Open wounds, as a class, include all in which there has been a breach of the skin or mucous membrane.

Open wounds are subdivided, according to the manner in which they are produced, into *incised*, *punctured*, *contused*, *lacerated*, *gunshot*, or *poisoned* wounds, according as the wounding agent has been a sharp cutting edge, a penetrating point, a dull and bruising body, a tearing force, a projectile impelled by the force of an explosive, or one which carries with it into the wound a poison. *Penetrating* wounds are those in which the vulnerating body enters a cavity without emerging; *perforating* wounds, those in which the vulnerating body both enters and emerges from the cavity.

All wounds are accompanied by death of tissue in their track; even the path of the keenest knife-edge through a tissue is lined by disorganized particles that have been killed by its impact. Between a slight and clean incised wound, in which the destruction of tissue is limited to the molecules traversed by the

cutting instrument, and an extensive lacerated wound, with roughly torn and contused edges, or between a slight bruise and a contusion producing the death and disorganization of large masses of tissue, the difference is one of degree and not of kind. The important practical difference which has always been recognized in the healing of these different classes of wounds depends simply upon the difference between the facility with which the devitalized tissue is prevented from becoming a source of disturbance to the healing of the wound in the several instances.

Wounds may be again classed as *aseptic* and *septic*. *Aseptic wounds* include all which are preserved from contamination by poisonous bacterial products, whether such poison come in contact with the wound directly or be generated in it by the action of germs that gain access to it. An aseptic condition in a wound may be obtained either by the protection which the wound received from the first against the access of any septic agent, or by the power of tissues to resist and destroy septic agents, or by the application to the wound of substances which destroy them. Subcutaneous wounds, as a rule, remain aseptic in consequence of the protecting covering which the skin affords; operative wounds inflicted under certain precautions may be aseptic; all open wounds in which union by first intention is secured without special and adequate aseptic precautions are examples of the power of living tissues to resist septic infection. *Septic wounds* include all those in which any agent capable of exciting fermentation or putrefaction lodges and grows. In all cases they are attended with some degree of inflammation and suppuration and with sloughing of dead tissue.

Symptoms.—The symptoms indicative of a wound are *local*, dependent upon the effects produced at the point at which the wound is inflicted, and *constitutional*, dependent upon the effects on the body at large.

Local Symptoms. — First, IMPAIRMENT OF FUNCTION. — A certain amount of disability is the inevitable result of a division of tissue. Its extent and nature will depend upon the amount of injury and the tissue injured. The duration of the disability will depend upon the promptness of healing and the susceptibility of the wounded tissue for perfect repair.

Divided tissues tend to retract from each other, and thus a greater or less amount of GAPING becomes a wound-symptom.

PAIN is a usual accompaniment of a wound. It is due to the irritation sustained by the sensory nerves. The amount of pain is of variable quantity. At the moment of the infliction of a wound no pain at all may be experienced, owing to mental preoccupation or excitement or to the rapidity with which the wound was inflicted. The temperament of the individual may modify the amount of pain. Some individuals experience great pain from causes which in others produce but little suffering. The sharp pain usually felt at the moment of the infliction of a wound soon gives way to a dull aching or smarting pain, which may last for some hours, but will finally subside and disappear, provided the wounded parts are kept at rest and their repair progresses without disturbance. Attempts at motion in a wounded part, which tend to pull apart the divided tissues, or the occurrence of a high grade of inflammation, causing tension and excessive congestion, awakens pain anew. When large sensory nerve-trunks have been involved in wounds, later and continuous pain may be due to slight inflammatory conditions extending from the wound upward along these nerves; hence the pain often complained of in the stumps of amputated limbs during the first few days following operation.

HEMORRHAGE.—Some amount of bleeding is the immediate effect of every wound. It is always the invariable and most manifest symptom that a wound has been inflicted, but the amount of the blood lost may vary greatly according

to the constitutional condition of the wounded person, to the character of the tissue wounded, and to the size of the blood-vessels implicated. In scorbutic conditions of the system, and in those occasional instances where a hemorrhagic diathesis exists, prolonged and even dangerous loss of blood may result from a trifling wound. Ordinarily, when merely capillaries or small arterioles or venules are divided, spontaneous cessation of hemorrhage quickly occurs, especially if the tissues wounded are retractile, so that the wounded vessels become withdrawn among and embraced by them. Whatever favors the production and retention of a clot about a wounded vessel favors the arrest of hemorrhage; hence lacerated wounds, where the wound-edges are ragged and the openings of the vessels themselves irregular, the coats of the larger vessels, being unevenly divided, are not likely to bleed much, on account of the entanglement of the blood-fibrin in the irregularities of the wound-surfaces and the speedy production of blood-clot. When large blood-vessels are opened profuse and speedily fatal hemorrhage may occur.

SHOCK.—The primary constitutional symptom of a wound is “shock.” Shock is that condition of general vital depression which marks the immediate effect upon the individual as a whole produced by the local wound. It may be of any grade of intensity, from a slight, evanescent, and hardly appreciable disturbance of mental force to the most profound general depression and speedy death. Its manifestations are through the nervous system, and are exhibited most markedly by depressed action of the circulatory organs—vasomotor paralysis. Shock is to be distinguished from the effects of hemorrhage; and in cases of surgical operations from the effects of anesthetics, although in many instances it may be aggravated by either or both. Martin and Hare have recently proposed to use the hemoglobinometer as a means of distinguishing hemorrhage, especially intra-abdominal, from shock. In shock the hemoglobin would be unaltered; in hemorrhage the hemoglobin would be greatly diminished. The pathology of shock cannot be determined by the ordinary methods of research. In such cases death leaves no change which can be detected in any of the tissues. The effects manifest themselves chiefly through the agency of the nervous system in the same way as all the phenomena of life which are controlled by that system. Sometimes, however, as seems to have been shown by Goltz, a marked distention of the intra-abdominal veins exists. The phenomena of shock must be accepted as the measure of the ability of an individual to resist hurtful influences from without. The same injury will produce different degrees of shock in different individuals, and different degrees likewise in the same individual at different times. Women, as a class, are less susceptible to shock than men. Persons who are inured to suffering, or who by long confinement to bed or by the influence of drugs have acquired a certain torpidity of the nervous energies, are less susceptible to shock than individuals whose nervous forces are in a high degree of activity. Temperament modifies the manifestations of shock. The phlegmatic and lymphatic temperaments resist shock; the sanguine and mobile temperaments favor it in the highest degree. Mental conditions modify shock; fear, despair, despondency, disappointment, depressed mental states of any kind, aggravate shock; on the contrary, hope, joy, cheerfulness, glad expectation, success, diminish shock. Age modifies shock. The young bear injuries well, and rally quickly from shock when unaccompanied with much loss of blood; in the aged the frequent presence of organic disease often renders shock more severe and prolonged. In the absence of organic derangements the dulled nervous susceptibility of the aged diminishes their liability to shock.

Symptoms of Shock.—The symptoms of shock are those of general depres-

sion: the skin is pale and cool; the pulse is feeble and rapid, the respiration is shallow and irregular; the body-temperature is lowered; a sense of faintness is experienced by the individual, and in the more severe forms total loss of consciousness ensues; the functional activity of all the organs of the body is retarded; muscular tone is diminished, with a sense of general muscular powerlessness; the sphincters may fail to act, causing involuntary evacuations; nausea and vomiting often occur. Every degree of intensity in these symptoms of depression which have been enumerated may exist in different cases, from a transient feeling of weakness and momentary mental confusion to absolute death. The symptoms of shock are the immediate consequence of the injury sustained. The assumption of the possibility of a condition of delayed shock is not consistent with what has been said as to the nature of shock itself. Whenever a condition of sudden and marked depression declares itself some time after the reception of an injury, it is always due to some distinct cause other than the original injury, and when recovery from shock is delayed and manifests oscillations of improvement and retrogression, distinct diseased conditions, possibly directly resulting from the injury, are always its cause. For this reason the terms which are found in older text-books, and which are still often used in ordinary surgical parlance—namely, delayed shock, secondary shock, and imperfect reaction from shock—may be misleading, as they tend to divert the attention from real conditions. The conditions which most frequently cause these symptoms of later depression are concealed hemorrhage, septic infection, and fat embolism. Pulmonary oedema and renal congestion are also possible conditions always to be inquired after when a sudden unfavorable turn occurs in the condition of a patient soon after an injury has been sustained, especially when ether has been used as an anesthetic. The occurrence of any of these conditions may, of course, produce its own shock, but this shock arises *de novo*.

Prognosis of Shock.—Very quick and complete recovery from a state of most profound shock may occur. The chief elements upon which recovery from shock depend are these: First, whether the injury has to do with a vital part; and second, whether it entails a continued source of irritation and depression. Thus in injuries to the head the immediate shock may be overwhelming in consequence of the vital relations of the injured part, or when not at once fatal may be continued and masked by inflammatory conditions arising in the cerebral tissues as a consequence of the injury. So in crushing injuries of the extremities: the immediate shock of the injury may be prolonged and intensified by the pain and irritation arising in the mangled tissues, so that the surgeon is often called upon, even in the presence of much general shock, to run the risks of subjecting his patient to the additional brief shock of an amputation, rather than to leave him exposed to the continued irritation of his mangled limb, with possible added septic infection, while waiting for reaction to be established. In general it may be said that when an injury is not primarily fatal through shock, and continually renewed shock can be prevented, speedy recovery therefrom may be confidently looked for under proper treatment. Severe shock is so often complicated with the acute anemia caused by loss of blood that it is difficult to separate its prognosis and its treatment from those of the latter condition; nor in practice is it essential to do so.

Reaction.—The symptoms which indicate the passing away of the effects of shock are a gradual increase of the strength and volume of the pulse, a diminution in its frequency, a more natural color and heat of the skin, return of consciousness, and the manifestation of muscular power, as the shifting of his position by the patient. The appearance of such favorable symptoms constitutes what

is termed a state of *reaction*. In the most favorable cases reaction is gradual and progressive, though it may occupy many hours or even days in its course. Returning color to the face and an increased power in the heart's action are unmistakable signs of its occurrence. In certain cases fluctuations in the reaction occur, relapse alternating with improvement for a variable time. The real significance of such fluctuations has already been dwelt upon. In other cases, before perfect reaction has been accomplished, there supervenes a condition characterized by a rapid and weak heart's action, cerebral excitement and delirium, muscular tremor, and high body-temperature. These are the signs of septic infection. Reaction from shock is commonly attended by some elevation of the body-temperature, quickening of the pulse, thirst, derangement of the secretions, restlessness, and headache. This fever attending reaction may be so trifling and evanescent as to escape notice. Its grade of severity depends chiefly upon the nervous activity of the patient, his previous constitutional condition, and the amount of local irritation produced by the injury. Children manifest it most readily. It makes its appearance usually within a few hours after the reception of an injury, and may be expected to decline on or after the second day. This aseptic fever is to be distinguished from the traumatic or surgical fever which sometimes complicates the repair of injuries, which does not develop until two or three days after an injury, and which is dependent upon general blood-infection by absorption of septic matter from the injured part.

Prophylaxis of Shock.—In cases of surgical operations it is possible for the surgeon to diminish to some extent the shock resulting from the wounds inflicted. These means include moral, physical, and medicinal measures. The patient should be inspired to believe that success will crown the surgeon's efforts, and to place implicit reliance upon his skill. However plainly the surgeon should state the possibilities of mischance to the friends of the patient, nothing but hope and happy expectation should usually be expressed to the patient himself. Among physical means are included all measures of a general character which tend to diminish nervous irritability and promote the general resisting power of the individual. Confinement to the bed for some days is of value as a nervous sedative. The regulation of all the secretions of the body so as to secure as nearly a perfect condition of well-being as possible is not to be overlooked. The choice of the period of the day for operating when the vital powers are at their best is likewise to be considered. As a rule, this is during the morning hours. All unnecessary exposure of the body occasioning loss of body-heat is to be avoided; if the operation is to be long, artificial heat by hot-water bags and bottles should be applied during the operation. Hemorrhage is to be carefully guarded against and restrained.

Medicinal measures include the use of narcotics, as opiates, the bromides, and the free administration of alcohol. These may be of benefit when a state of excessive nervous irritability has to be antagonized. They are of special value in preparing alcoholic subjects for operation. In patients the subjects of malarial cachexia the free preliminary use of quinine should be resorted to. The administration of an anesthetic should be conducted with great care, lest the depressing effect of excessive anesthesia should be added to that of the surgical procedure, but at the same time complete anesthesia should be secured. For the same reason, while avoiding undue haste, operations should be done as quickly as possible. Strychnia may be used hypodermatically in full medicinal dose, $\frac{1}{20}$ to $\frac{1}{10}$ of a grain, after anesthesia has been induced, at the beginning of serious surgical procedures, as a prophylactic against shock through its stimulating action upon the cerebro-spinal centers.

Treatment of Shock.—Shock, having once become established in a severe degree, requires prompt treatment. If it occurs in the course of a surgical operation, the operation must be brought to a conclusion as speedily as possible, or may even have to be suspended. The head should be lowered and the body placed in the recumbent position, if it is not already so. Respiration should be kept free from impediment, and when practicable the stimulating effect of inhalations of oxygen should be resorted to. Heat should be applied not only to the extremities, but to the whole surface of the body as far as practicable. Hot-water bottles and hot blankets should have been provided for this purpose. In cases of severe shock an efficient and speedy method of applying heat is to wrap the whole body in blankets wrung out of hot water. Injections of a pint of warm normal salt-solution (3j to Oj) may be made under the skin or into a vein. Diffusible stimulants should be instantly and freely administered. Hypodermatic injections of whiskey or brandy in doses of one-half to one dram should be given every five or ten minutes until a distinct effect from them can be discerned by a more full, slow, and regular pulse. A rectal enema of turpentine (f3ss-j), rubbed up to an emulsion with a raw egg in warm water (f3iv), acts as a powerful stimulant. A warm strong infusion of coffee will be of much use. In digitalis and atropine two most valuable remedies for sustaining a flagging heart are found. They should be administered hypodermatically, the tincture of digitalis in fifteen-minim doses every fifteen minutes till the pulse is affected; not more, however, than four such doses should be administered consecutively. If any benefit is to be obtained from the remedy, it will have been developed by that time. The first dose of digitalis may be combined with one one-hundredth of a grain of atropia. When the pulsations of the heart become more slow and regular, and the superficial capillaries show that the blood-stream is again filling them, and an increasing muscular power and general well-being is beginning to be established, a gradual withdrawal of these stimulating measures is to be practised; the pulse is to be watched, and according to its indications of recurring weakness or progressive strength the stimulants and cardiac tonics are to be resorted to anew or entirely withdrawn. When the patient begins to complain of the temperature of the hot appliances by which he has been surrounded, they may be removed. Where there has been much hemorrhage the copious administration of hot liquids by the stomach and by the rectum should be resorted to to the full amount which these organs are able to dispose of. Recovery from shock under proper treatment, if it occurs at all, is usually quite speedy; delay in recovery or alternations of improvements and relapse, as has already been stated in a preceding page, are due to the nature of the injury itself or to new complications introduced, and are not to be attributed to or classed as shock.

Death from shock may be immediate or gradual. When instantaneous death takes place the nerve-centers must be considered as having been overwhelmed beyond the power of resistance. In some such cases the heart has been found contracted and empty. More commonly the fatal issue occurs only after some minutes or hours of struggle against the inevitable. The fatal approach is then more gradual; the action of the heart becomes more and more feeble; the pulse, weak and thready and counted with difficulty on account of its rapidity, becomes finally lost; the extremities become cool, the face pinched and haggard; the mind, apathetic, gradually sinking into unconsciousness; the temperature continues to fall until it becomes a degree or more subnormal; the respiration is feeble and shallow, until finally, by combined respiratory and cardiac failure, death closes the scene.

FAT EMBOLISM.—Injuries, especially those of bones and of soft parts involving much adipose tissue, when there is much crushing of the parts, through the fact that many fat-cells are broken down and minute fat-globules set free, mingling with the effused fluids and wound-secretions, may exhibit a train of symptoms which are due to the entrance into the circulation of this fluid fat. The condition is known as fat embolism. In extensive compound and multiple fractures its most severe forms are likely to be developed, causing symptoms complicating and succeeding those of shock, and often resulting in death. These deaths have commonly been attributed to shock; their real cause has only been appreciated within a few years, and even now is frequently overlooked. Fat embolism is rare in children, because their skeletons contain relatively little fat. The severity of the symptoms depends on the quantity of fat which has gained entrance to the circulation, on the rapidity with which it has entered, and on the proximity of its source to the heart. Having once gained access to the general venous current, the fatty globules are carried to the right heart, and thence are driven with the blood-stream into the pulmonary capillaries, which they plug up to a greater or less degree, and by their presence here determine the first symptoms of fat embolism. When the amount of fatty material which is poured into the capillaries of the lungs is not very great or when it arrives but slowly, the disturbance which it causes may be but slight; gradually the oil-molecules are forced through and pass on into the general circulation. They may now again be arrested in the capillaries of the brain or spinal cord, and here excite the special disturbances incident to lesions of these organs. More frequently they are arrested and disposed of in the liver and in the kidneys. The urine secreted by kidneys thus blocked up by fat will present oil-globules floating on its surface.

The *symptoms of fat embolism* as a rule develop within from thirty-six to seventy-two hours after an injury, though fatal cases are recorded in which the symptoms developed and ran their entire course in less than twelve hours. The symptoms indicative of the lesser degrees of fat embolism are restlessness, anxiety, slight dyspnea, and accelerated breathing, with quickening of the pulse. In the more severe degrees these conditions become aggravated, general prostration rapidly increases, the countenance becomes pallid and anxious, and later cyanosis, mental excitement, delirium, somnolence, and coma succeed in turn. The dyspnea becomes intense, the respiration very rapid, and finally stertorous. *Edema pulmonum* develops; hemoptysis may occur; the pulse is weak, frequent, irregular, and finally imperceptible. The temperature at first is subnormal, and may remain so, or may rise later, according to the development of secondary complications. The urine will display oil-globules floating on its surface.

Diagnosis of Fat Embolism.—Fat embolism is to be distinguished from shock, the effects of anesthetics, acute septicemia, acute congestions of the lungs and of the kidneys, and cerebral hemorrhage or embolism. It is to be distinguished from shock by the fact that its symptoms make their appearance at a time when the symptoms of shock should have greatly subsided, and in many cases where in the first place the amount of shock has never been very great. The remote effects of ether are not so easily to be distinguished from the effects of fat embolism. The irritative effects upon the lungs and the kidneys of the prolonged administration of ether to persons predisposed to pulmonary or renal congestion often declare themselves in severe congestion, which determines symptoms not unlike those of fat embolism. In cases, therefore, in which such administration of ether has been resorted to the diagnosis may be

made obscure. The appearance of oil-globules floating on the urine would be sufficient to determine the presence of fat embolism. The symptoms of acute septicemia are later in their development than those of embolism. They are accompanied by marked elevation of temperature. They are more gradual in their onset, however active their course may be, and not infrequently are engrafted upon those of fat embolism. The sequence of the conditions of shock, fat embolism, and acute septicemia is not infrequent, and, when its possibility is borne in mind by the surgeon, will readily explain the course of many otherwise anomalous cases. Acute inflammatory states of the lungs arising from conditions entirely independent of fat embolism may develop rapidly after operations or injuries, and are to be distinguished from the effects of fat embolism, which may also be present and which may be masked by them. The symptoms indicative of such acute inflammatory lung congestion are sufficiently clear for diagnostic purposes if attention is only directed to them. The danger is rather that the symptoms of fat embolism will be confounded with them than that they should be mistaken for fat embolism. The not infrequent occurrence of acute renal congestion, with total arrest of the urinary secretions, after a severe operation, is to be borne in mind by the surgeon in making his diagnosis as to the cause of threatening symptoms which complicate or supervene upon the shock of the original operation or injury. The disturbance of cerebral conditions likewise, through embolism or cerebral hemorrhage, is to be borne in mind as a possible occurrence.

Prognosis of Fat Embolism.—When the symptoms indicating the presence of fat embolism are severe the probabilities of recovery are very slight. In its lesser degrees the disturbances caused by it are transient and are speedily and spontaneously recovered from. The prognosis depends upon two factors especially—the amount of fat that has gained access to the circulation, and the ability of the heart to force the oil-globules through the capillaries of the lungs. Should this first danger have been overcome, possibilities of renewed danger from arrest of oil-globules in the capillaries of the brain or spinal cord in vital regions still exist. In such conditions a fatal result is not long delayed, a few hours only sufficing to bring the case to a close. When the pulmonary trouble is the chief one, a longer time may be required to determine the final result, whether recovery or death. At best, however, the struggle is a brief one, and is determined one way or the other within less than forty-eight hours.

Treatment of Fat Embolism.—The first indication for treatment is to prevent, if possible, and at all events to diminish, the entry of fatty matter into the blood-current. The two conditions that foster this accident are the churning up of bruised and broken fatty tissue by movements of a part, and the tension resulting from the accumulation of wound-secretions that have no vent. Immobilization of the injured part and relief to tension by provision for free drainage are therefore of primary importance. The second indication for treatment is to sustain and stimulate the action of the heart. For this purpose alcohol, digitalis, and strychnia in full doses will be found useful.

REPAIR OF WOUNDS.

The repair of all breaches of tissue is accomplished by essentially the same process, subject only to minor peculiarities of structure. This process has been described in a preceding section (Process of Repair). By reference to this section it will be seen that the essential element of repair consists in a modification of the normal nutritive processes at the seat of injury, by which the tissues to be repaired return to their embryonic state and new embryonic tissue

is formed between them, with which they blend. By the organization and development of the new tissue a permanent bond of union is formed. In no case is union of divided tissue effected without the interposition of new material. When divided tissues are at once brought into perfect apposition, and there retained and shielded from disturbance, the amount of new tissue required for the accomplishment of union will be extremely small, and may be with difficulty recognizable; but its existence in some degree is nevertheless undeniable.

When the process of repair whereby the union of divided surfaces is secured proceeds without complication or interruption, union by first intention or by primary adhesion is said to have taken place. (See Chapter III.) This primary union is the ideal to be sought for whenever possible. To secure it it is necessary that the divided surfaces be brought together and kept in close apposition; that the wound be protected and kept from all further injury; and that adequate local nutritive conditions be maintained. Whatever interferes with any of these conditions will introduce a complication in the healing of a wound. It is not infrequently the case that wounds occur in which from the outset it is apparent to a surgeon that in some one or all of these respects it will be impossible to secure the necessary conditions, so that no attempt to secure union by first intention can be made. Thus the loss of tissue may be so great that apposition of the divided surfaces is impracticable, or some motion is unavoidable, or there is pre-existing infection, or such relation of the wound to the bodily excretions or secretions exists that some contamination is inevitable. The presence of any of these conditions will make it obvious that a wound should not be closed. Again, the tissues bordering the wound may be so bruised or reduced in their vitality by general or local causes that their power of sustaining the necessary processes of repair is uncertain, perhaps obviously hopeless. In all such cases the method adopted by the surgeon for the treatment of the wound will be quite different from those in which primary union is expected. Healing by second intention is the process which is now the resource of the surgeon, as it is also in those cases in which attempts at primary union have been made and have failed. By its means the ultimate healing of the wound is secured.

The conditions which may thwart the ideal primary repair of the wound will have to do with either the apposition, the protection, or the nutrition of the wounded parts. Under the first of these headings the surgeon must consider the natural gaping of divided tissues and the necessity of supplying adequate means of retaining them in coaptation. The inevitable aggravation of this natural gaping by certain positions of the body or of the limbs and by motion at joints suggests at once the necessity of considering a favorable posture for wounded parts, so that relaxation of the injured tissues as complete as possible may be secured. The accumulation of blood and of wound-secretions between the divided surfaces is a frequent cause of lack of success in attempts at securing primary union. Under conditions of typically perfect protection from external infection, as in most subcutaneous wounds, and in some operation-wounds made under rigid conditions of asepsis, such accumulations of blood and wound-secretions may not introduce any serious complication into the healing of the wound. Later, these effusions become absorbed, or they are diffused among the adjacent connective tissue-spaces, and the natural processes of repair proceed. In yet other cases the blood-clot, remaining as an intervening mass between the wound-surfaces, serves as a support and scaffolding for new tissue which is thrown out from the surrounding parts, and which penetrates the mass of the clot and coalesces with it, and finally replaces

it by fibrous tissue that unites the previously separated wound-surfaces. Union by secondary intention is thus accomplished without suppuration or waste of nutritive material. As a rule, the most assiduous effort of the surgeon must be to prevent any accumulation of blood or wound-secretions in any wound which he is called upon to treat. Perfect apposition may, again, be prevented by the presence of foreign matter between the wound-surfaces. Shreds of clothing, splinters of wood, sponges, bits of foreign matter of every conceivable character, at times are found in wounds, and their removal is to be carefully secured by the surgeon.

For the protection of a wound it is requisite that it be guarded first from motion, since by motion the apposition of the wound-surfaces is disturbed, the delicate new adhesive material which has already been formed is ruptured, and the conditions of the original injury are renewed in tissues already weakened by that injury. The wound must be protected also from mechanical violence, such as rude handling, friction, and gross mechanical injuries of every kind. It must be protected from chemical irritants, and especially from the products of decomposition of retained secretions or of portions of dead tissue; and, lastly, it must be protected from infection from poisonous agents, especially the more common infecting organisms everywhere abounding in nature.

The local nutritive conditions to which attention must be paid have to do with the circulation and the innervation of the parts to be repaired. A dependent position of the injured part or an impediment to the free return circulation by improper bandaging may produce excessive and persistent congestion and interfere with its repair. Temperature is not unimportant: prolonged cold will impair nutrition, and too high a temperature may cause local death. Too great tension of wound-flaps or tension from pent-up secretions impairs local nutrition by obstructing the flow of blood in the capillaries, as well as by the reflex effects of irritated nerve-fibrils, and also mechanically prevents rest and coaptation of deeper parts. The details of treatment to be applied in every wound have their rational basis in the principles thus outlined, which will serve for the safe guidance of the practitioner.

Treatment of Wounds.—*Arrest of Hemorrhage.*—To stop bleeding is the first care of the surgeon in his treatment of a wound. The physiology of spontaneous hemostasis and the methods of securing artificial arrest of hemorrhage are given at length under Injuries of the Blood-vessels. The aim of the surgeon should always be to secure the arrest of bleeding by means that shall cause the least disturbance in the future repair of the wound. Unnecessary ligatures are therefore always to be avoided. When ligatures are unavoidable, those made of absorbable material, as catgut, are to be preferred, and the size of the thread should be as small as is consistent with the strength required to occlude the vessel. When non-absorbable materials are used for ligatures, as silk thread, if it has been perfectly disinfected and primary union of the wound can reasonably be expected, this too may be cut off and left buried in the wound. The first and most generally applicable means for restraining hemorrhage is that of direct pressure made upon the bleeding point. This may be by the finger or by a tampon, or by an instrument, as a pressure-forceps. These means are often, in the nature of the case, but temporary expedients. In many instances, however, the temporary use of pressure will be all that will be required for the arrest of hemorrhage that at first was very abundant. When copious and continuous capillary oozing persists, it may frequently be controlled by pressure with compresses wrung out in water as hot as can be born by the hand—115° to 120° F. The use of heat as a hemostatic is to be preferred to cold, as being more favorable to local nutrition and subse-

quent active repair. The use of hemostatic forceps, which when once applied automatically compress the orifices of bleeding vessels, is a very efficient and convenient means of applying pressure. Many vessels, which at first bleed freely, after a few moments' compression in this manner will no longer bleed when the forceps are removed. If the bleeding does persist, torsion may be applied, which, being effectual in many instances, will reduce the ultimate need for ligatures to a minimum. As a rule, hemostatic agents which produce tough clots of blood, as the salts of iron, or which are strong irritants, such as turpentine, or which destroy tissue outright, as the actual cautery, are to be carefully avoided. The free access of cold air is an active hemostatic and the least harmful. Often when continuous oozing persists from a wound under a mass of soft blood-clot, if the wound is freely opened and the accumulated clot thoroughly removed further oozing becomes definitely arrested. A dilute solution of iodine has both hemostatic and antiseptic properties, and may sometimes be used with advantage. Iodoform added to a compress applied upon a bleeding surface has a distinct hemostatic effect. From among all these resources the surgeon will be called in a given case to make use of those which shall be available, efficient, and least harmful, keeping in view always the ideal of wound treatment—subsequent union by primary intention.

Complete immediate hemostasis is not to be sought for in the treatment of wounds in which easy apposition of the wound-surfaces cannot be obtained, and in which dead spaces or open defects remain which it is possible for the surgeon to fill in by tissue organized in and supported by a moist blood-clot. When a surgeon is master of a sufficiently perfect antiseptic technique to secure healing under such a blood-clot, and the circumstances are favorable, he may make the attempt. He will then encourage, or even provoke, sufficient bleeding to fill up all the dead spaces and the wound-defects with blood previous to the application of a dressing, and will subsequently protect the clot from adhesion to or disturbance by the external dressing. (See page 29.)

Cleansing of the Wound.—Great care should be taken to remove from a wound not only all foreign matter which may have been deposited within it, but also all dead or dying tissue, and, as a rule, all blood-clots. The means required for effecting such cleansing must be adapted to the nature of the material to be removed. The forceps, scissors, curette, sponge, irrigating stream, each may find its use. By means of these simply the more gross and perceptible impurities may be removed. Of greater importance oftentimes is the cleansing of the wound of those microscopic organisms which may induce suppuration and putrefaction. (For the consideration of the means required for this latter degree of cleanliness or sterilization see Operative Surgery.) Suffice it here to say that in his treatment of wounds the surgeon should never lose sight of the natural resisting power of living tissue to such organisms, and that in his efforts at sterilization he should irritate and injure the living tissue as little as possible. Strong and irritating antiseptic lotions are therefore, as a rule, to be avoided as direct applications to wound-surfaces.

When, however, a wound is already manifestly contaminated, it will be good practice to irrigate it thoroughly for a considerable period of time with a germicidal lotion of sufficient strength to secure the destruction of whatever septic material may have gained access to it. A solution of carbolic acid, 1:40, or of corrosive sublimate, 1:1000, will be found most generally suitable for such a purpose. When the full sterilization of a wound, even by the use of antiseptic irrigations, is impracticable, or it is so situated that it cannot be kept free from subsequent renewed contamination, as in many wounds involving the outlets of mucous canals or when the wound opens into suppurat-

ing cavities, resort must be had to tamponing the wound-cavities with materials impregnated with a permanent antiseptic, as iodoform or boric or salicylic acid. In these latter cases, of course, union by granulation is what commonly occurs, but what is practically primary union may sometimes be attained by "secondary sutures."

Coaptation.—In the coaptation of wounds the aim of the surgeon must be to bring the severed parts as far as possible into the same relations with each other as existed before the wound was inflicted, and especially to secure the closest possible apposition of every portion of the wound-surfaces. When important nerves, muscles, and tendons have been divided, especial care must be taken to bring and secure together the divided ends; all dead spaces where secretions may gather are to be prevented; and by various means and devices the tissues are to be retained in their restored relation until definite reunion has been accomplished. Under the term "coaptation" all the various aims and methods referred to are included. In the section devoted to Minor Surgery the means of accomplishing coaptation are described in detail. Here, however, it will be proper to speak of the general principles which should guide the surgeon in the choice of means and methods.

First, much tension must be avoided. When tissues are put unduly upon the stretch in an effort to bring them together, the circulation of the blood within them is impeded, nutrition is impaired, the formation of sloughs is invited, and suppurative disturbances are promoted. It is far better to be content with whatever amount of coaptation can be easily secured, and to seek for the healing of any surfaces left uncovered, either by granulation and ultimate cicatrization or by skin-grafts. In the second place, care must be taken while securing coaptation to avoid such adjustment of sutures or other retentive apparatus as would be likely to produce strangulation of any portion of the tissue. Sutures too closely applied and too tightly drawn are a frequent cause of necrosis of wound-edges; the pressure of compresses and bandages may likewise be so great as to produce local tissue-necrosis, so that good judgment should always be used in their application. Thirdly, the relaxation of tissues by position should not be overlooked by the surgeon. The spontaneous gaping or falling together of wounds in varying attitudes of a wounded part need but be noticed to suggest the advantage to be derived from placing a part in that position or attitude in which any tendency to gape during the healing process will be reduced to a minimum. The general rule is, therefore, in order to favor coaptation of a wound, to put the part in that position in which the greatest relaxation of the wounded structures can be secured, and in this position they should be fixed and held until firm union has been accomplished. As an accessory to the use of position for securing relaxation is the device of sliding toward the wound tissues somewhat distant from it. By the use of sutures traversing a deeper portion of the wound, and made to embrace portions of tissue on either side at a considerable distance from the wound-edges, and then secured after the manner in which an upholsterer secures the two sides of a mattress together, wounds which gape widely at first may often have their edges so approximated that they are easily brought together without tension.

The choice of materials for ensuring continued coaptation is worthy of consideration. When a wound is small and there is no tendency to gape, or when that tendency has been overcome by attention to position, the use of a simple compress held in place by a roller bandage may be all that is required to ensure undisturbed healing. In general, however, additional means for securing undisturbed coaptation will be required. For this purpose are used adhesive strips and sutures.

Adhesive strips, as direct applications to wound-flaps to secure their apposition, should rarely be used. Being disinfected with difficulty, they are always to be looked upon as surgically unclean. They favor infection likewise by retaining wound-discharges underneath them and in their substance; they cover up a wound from the surgeon's inspection; they often irritate the skin to which they are applied; and, finally, from their tendency to become loosened, they are unreliable in the support which they give. Strips of gauze fixed with collodion are more effective and are perfectly aseptic. For purposes of supplementary support, however, placed *outside* of the immediate wound-dressing to prevent tension, to produce compression, and to ensure fixation of the dressings, adhesive strips are invaluable.

Sutures.—The most certain, exact, and generally available of the means for retaining divided surfaces in coaptation is the suture. As "stitches of coaptation," applied superficially and close to the wound-margins, they keep the cutaneous edges of the wound together. As "stitches of approximation," having been passed more deeply and at a greater distance from the wound-margins, they approximate and hold together the deeper surfaces. As "stitches of relaxation," embracing tissues at some distance on either side of the wound, they relax the adjacent tissues, so that the wound-surfaces may be brought together and tension be avoided. The materials available for sutures will be discussed elsewhere. (See Operative Surgery.) Whatever form of thread is chosen should have been rendered aseptic by previous preparation, and should likewise be immersed anew in the antiseptic solution at the time it is used.

Drainage.—As the surgeon proceeds with his efforts at securing coaptation of a wound he must make provision for the escape of the secretions which are the immediate result and accompaniment of every wound. When perfect coaptation, deep as well as superficial, has been secured, and when by the most scrupulous and exact observance of antiseptic precautions the surgeon is assured that his wound when dressed is as free from infection as a subcutaneous one, means of drainage may be dispensed with, and the local absorbents may be relied upon to remove whatever secretions are poured out in excess of the quantity needed for repair. As a rule, however, it will be important for the surgeon to provide means for the free and continuous escape of wound-secretions. It will often be sufficient to leave open the most dependent portion of the wound. In some cases enlargement of wounds by free incisions or the making of counter-openings may be practised for the purpose of securing free escape of secretions. In many instances it will be good practice to introduce the sutures at the operation, but not to tie them until after the cessation of the primary copious bloody and serous oozing which occurs during the first twelve to twenty-four hours after the occurrence of a wound (secondary suture). Septic infection having been prevented by the use of antiseptic dressings, at the end of this period the wound-surfaces may be brought together, with an increased probability of securing union by first intention without the necessity of any further means of drainage. Frequently, however, the surgeon will be compelled to resort to the introduction into a wound of some foreign material for the purpose of conducting away its discharges. This substance may act by capillarity, serving to keep the wound-surfaces apart and permitting the outflow of liquid along the interstices among its strands, or there may be provided tubes through which free flow of the discharge is secured. For the escape of pus a tubular drain is always required, and whenever provision is to be made for the escape of much secretion, if absolute certainty of drainage is desired such a tube must be used. Rubber tubing is the most universally applicable means of drainage, being

flexible, unirritating, easy to manipulate, easily sterilized, nearly always attainable, and cheap. A drainage-tube, of whatever substance composed, is a foreign body, and as long as it remains in a wound is liable to produce disturbance. It should therefore be removed as soon as the period of profuse secretion which made its original use necessary has passed away, or as soon as the cavity which it was intended to drain has become obliterated.

Dressings.—In the treatment of a wound after hemorrhage has been checked, its surface has been cleansed and purified, coaptation has been accomplished, and drainage has been provided for, a suitable dressing must be applied. Two main objects are to be accomplished by a dressing: first, the absorption of whatever secretions may come to the surface; and second, the protection from infection and from injury and motion. The materials which may be available for surgical dressings are fully treated of in the section devoted to Operative Surgery. Here, however, some general considerations concerning dressings are in place. Septic infection is to be guarded against by covering the part with soft and absorbent material that will receive and keep aseptic the discharges that drain away from a wound, and that will prevent the access of septic infection from other sources to the wound. For this purpose many substances may be found useful: among those more commonly employed are cotton wool, loosely-woven cotton cloth from which all oily matter has been removed, jute, sawdust, moss, etc. While all these substances are more or less hygroscopic, their usefulness as absorbent dressings depends chiefly upon the multitude of minute spaces existing between their meshes or fibers, and a certain degree of openness of mesh or looseness of fiber is requisite to enable them continuously to absorb thick and viscid fluids. It is not enough that these materials when applied should themselves be simply sterile, for when they are filled with wound-secretions they may then be infected from without and become the medium of conveying infection to the wound. It is better that portions of the dressings should themselves be impregnated with antiseptic materials, which could actively antagonize or inhibit the activity of any septic matter that might gain access to the secretions imbibed by them. The necessity of this is realized if the extreme difficulty, almost impossibility, of sterilizing absolutely the skin of the patient or the fingers of the surgeon is recalled. For this reason the best results in securing the healing of their wounds will be obtained by those surgeons, all other things being equal, who make use of wound-dressings containing proper proportions of corrosive sublimate, the double cyanide of zinc and mercury, boric or salicylic or carbolic acid, or similar antiseptic agents. By the use, further, of very voluminous dressings it is possible to give additional security against the conveyance of infection from without to a wound, and to protect it more certainly from mechanical violence and from motion.

Changes of dressings are made at long intervals, and thus the ideal rest is secured to the injured part while repair is going on. As to when such changes are required, various considerations must determine the action of the surgeon. The body-temperature of the patient, as indicated by the thermometer, should be especially relied upon as an index to the character of the processes going on in the wound. If, after an elevation of one or two degrees above the normal for the first forty-eight or seventy-two hours after a wound has been inflicted and dressed, the temperature sinks to nearly the normal point, and remains there with but slight fluctuation, the surgeon is assured that undisturbed repair is progressing, and that no demand for interference is present by reason of anything in the wound itself. If, however, the temperature continues elevated

after the first two or three days, or if, after having once fallen, it again rises, and especially if a series of morning remissions and evening exacerbations show themselves, the evidences are unmistakable that inflammatory and suppurative disturbances, with retention of secretion and septic absorption, are going on, and that a change of dressing with thorough exploration of the wound is required. When also the external layers of the dressings become moist with the secretions that have been imbibed from within, it is imperative that the dressings be renewed. This does not apply, however, to the frequent staining of the external layers of a dressing by the copious sero-bloody primary wound-secretion, which, when very hygroscopic materials are used, often occurs within a short time after the application of a dressing. In these cases the dressings quickly become and remain dry, and do not require to be changed. When drainage-tubes have been employed it is desirable that they be removed, in most cases, within a week or ten days, or often much earlier, for which purpose the dressing must be renewed. When for the purpose of controlling hemorrhage tampons have been left *in situ*, these should be removed as early as the third day, and thus they would form another indication for a change of dressing. If the wound becomes the seat of suppuration or of sloughing, such frequency of dressings is required as may be needful to secure the adequate drainage and cleansing of the infected part. In general, changes of dressings should be made as rarely as possible, and only for the purpose of meeting distinct indications. In changing dressings the same strict antisepsis should be observed as in the operation itself.

Local Treatment.—While proper attention is being given to a wound the needs of the wounded part should not be overlooked. Nothing which could interfere in any way with its most perfect well-being should be considered insignificant. The natural warmth of the part, perfect freedom of the circulation, the control of muscular spasm, and the most perfect quiet and comfort are all of importance to be secured.

Position.—A position that will be comfortable to the patient should if possible be selected. This will always be one in which the muscles are relaxed and the return circulation of the blood to the heart is favored. The relation of position to drainage should be kept in mind, and in the arranging of the means for drainage whenever possible the drains should be so placed as to be most efficient when the part shall have been placed in a position of the greatest comfort.

Compression.—Gentle, uniform, and continuous pressure is of great value in promoting rapid repair after injury. It restrains excessive local hyperemia, limits effusion, and promotes absorption of effusions already present; it antagonizes muscular spasm and contributes to rest of the part. A greater and more methodical application of pressure than is needful for maintaining simple apposition of the separated parts is required in order to obtain the full power of compression in favoring the repair of a wound. Compression should be smooth and uniform, gentle but firm, carefully avoiding any constriction. In most cases it may be best effected by covering the wounded part with layers of cotton wool and applying compression with bandages. The wool by its elasticity tends to distribute evenly the compression exercised by the bandage and to keep the pressure continuously uniform.

Immobilization.—While the means of compression just described will in many instances be sufficient to give whatever extraneous aid is required to prevent motion in the wounded part, in many others there will be needed some further assistance in securing the desired immobility. For this purpose splints of various kinds are available. Whenever any form of plastic splint can be

used, it should be chosen; such splints accurately take the shape of the part, forming a firm mould that encases and fixes the limb without pressing unduly on any one point. As a result, such splints are borne with comfort, and thus indirectly contribute still more to the well-doing of the wound. In an emergency, however, the ingenuity of the surgeon may be able to bend to his purpose, for giving support and fixation to a wounded part, a multitude of different substances.

Constitutional Treatment.—The existence of pain or general restlessness requires the administration of opiates for their relief. The age of the patient, his previous constitutional condition, the coexistence of disease or tendencies to disease, and the hygienic conditions in which he is placed, each must engage the attention of the surgeon in order that whatever special indications they present may be met, and every possible influence that might interfere with repair be guarded against. Even the mental state of the wounded should be regarded. The surgeon who is able to arouse hope, expectation, and faith in the minds of his patients will see their wounds heal more rapidly and certainly than when opposite states of mind exist. As regards the influence of age upon the healing of wounds, although in some cases aged persons display unimpaired ability to repair their wounds, yet as a rule in the aged healing is much more sluggish and more likely to suffer from disturbance. In aged patients especial attention must be paid to their nutrition, to maintaining their bodily warmth, and to giving them the stimulating effects of abundant sunlight and pure air.

In all cases whatever departures from a perfect standard of health a patient may present should engage the attention of the surgeon. Plethora, anemia, obesity; that peculiar vulnerability associated with the scrofulous diathesis; alcoholism; the exhaustion from overwork, underfeeding, or mental strain; the depression produced by vicious habits and the habitual inhalation of vitiated air,—these are some of the conditions for the relief of which the surgeon should see that proper constitutional treatment be given.

Closely allied to the conditions just named are certain well-marked diseased states, such as syphilis, tuberculosis, malaria, diabetes mellitus, and scurvy, which by the nutritive defects which they determine delay repair, often arrest it, and subject wounds to the most serious complications. The pre-existence of pyemia, septicemia, erysipelas, phlebitis, or any diffuse inflammation will add special dangers to any traumatism. Diseases of the various organs of the body, and particularly cardiac, pulmonary, hepatic, and renal diseases, modify the effects of wounds, both directly by the constitutional states which they create and which are unfavorable to repair and diminish the resisting powers of the tissues in general, and indirectly by the reaction of the injury upon the pre-existing affection, producing in it temporary exacerbation or permanent and excessive aggravation, with, not infrequently, speedy death. Each of the conditions named when present will demand constitutional treatment in order to neutralize as far as possible any influence for evil which it might exert upon the healing of the wound.

The general hygiene of the patient should be made as favorable as possible. Food insufficient in quantity or bad in quality, extremes of temperature, absence of sunlight, depressing climatic conditions, lack of exercise, insufficient and impure air,—these not only create previous constitutional conditions unfavorable to repair, but, when continued after the reception of a wound, directly diminish the activity of its reparative processes. The diet of the patient should be regulated so that his supply of food should be ample, palatable, and digestible, due regard being paid to personal taste and instincts.

In connection with the subject of alimentation attention should be paid to the action of the bowels and all the excretions and secretions of the body.

An abundant supply of sunlight and of pure air is especially important for the well-doing of a person who is confined by a wound to one place, and thus is dependent upon what is brought to him from without for the purification and renewal of the air which he must breathe. This is alike necessary for isolated cases in their own homes and for those in the crowded wards of a hospital.

After-Treatment.—The least possible interference with a wound while the healing process is going on is a cardinal principle in surgery. Too early and too frequent interference inevitably prevents the steady progress of the healing process. Infrequent dressing is eminently conducive to that absolute rest which is to be kept in view whatever method of treatment is adopted. When the first dressing of the wound has been conducted in accordance with the principles that have been described, the after-care from the surgeon will be limited to a watchful oversight of the means of protection and immobilization, of drainage, and of apposition that have been employed, so that they may be removed, substituted, or reinforced by others as soon as they are no longer called for or have become inefficient. The prevention of the access of septic organisms, and the removal as fast as formed of materials that may decompose or become the lodging-places of these organisms, constitute two great indications, to fulfil both of which the surgeon must continually strive to the best of his ability if he would acquit himself of reproach for the results of disturbance that may supervene in the progress of the wound. Inflammatory, erysipelatous, gangrenous, or septicemic complications attacking wounds are not always to be regarded as unfortunate and unavoidable accidents, but must sometimes be accepted as the results of errors or failures in the treatment which the wounds have received. When in the first dressing of a wound it has been possible to close it after perfectly satisfying the indications for treatment that have been detailed, it should not be disturbed until a sufficient time has elapsed for the adhesion of the wounded parts to become firm. From ten to fourteen days may often be permitted to pass before the dressings are removed. The indications which might call for earlier interference, such as the removal of drainage-tubes, have been detailed in a preceding paragraph; but whenever the external protective dressings remain dry, the wound is free from pain and fetor, and there is no acceleration of the pulse or elevation of the temperature, the dressings may be left undisturbed. Sutures may be allowed to remain as long as their support seems to be desirable, provided they are not causing irritation or supuration. In the latter case they should be removed at once. It is impossible to fix arbitrarily the periods for the renewal of the dressings: each case must be a law unto itself. In the changing of the dressings and in all the manipulations required about the wound the utmost gentleness should be used.

INTERCURRENT COMPLICATIONS.

The regular course of the healing of a wound may become disturbed by inflammation, entailing suppuration and possibly gangrene, and if healing is ultimately secured it is accomplished only by a prolonged process of granulation. By the absorption into the general circulation of materials formed in wounds thus complicated the general phenomena of septicemia and of pyemia may be produced.

INFLAMMATION.—With but few exceptions an inflamed wound is a septic wound, and the cause of the inflammation is the irritation of the products of

decomposition of retained secretions. It is accordingly those wounds in which the retention of secretions is most difficult to prevent, as of wounds of joints and other cavities, wounds leading down to fractured bone, and deep irregular punctured wounds, in which severe inflammation is frequently met with. To give free vent, therefore, to all wound-secretions that may have been retained is the first thing to be attended to in the treatment of such a wound. This may require nothing more than the cutting of a stitch, so that the natural gaping of the wound may suffice for the required vent, or it may require counter-incisions and the use of drains. Whenever an inflammation shows a tendency to spread into the adjacent parts, abundant, thorough, and systematic incisions into the affected area must be made, sufficient to provide for the free escape of all irritating secretions. Wherever there is a possibility of a foreign substance having been left in the wound, such as a splinter of wood, a piece of glass, a rusty nail, a bit of clothing, a detached piece of bone, etc., it should be carefully sought for and removed. If the inflammation has been caused or aggravated by mechanical irritation, by motion, or by the premature use of the wounded part, the recognition of such a fact will at once lead to its correction. When the causes of the inflammation have been removed, the parts should be placed in an elevated and comfortable position and subjected to such additional means for relieving the pain, heat, and swelling of the part, and overcoming the vascular congestion on which these depend, as the judgment of the surgeon may determine. In brief, however, it may be said that for the relief of inflamed wounds the surgeon will find of especial value the use of irrigation with cooling antiseptic solutions.

GANGRENE.—The appearance of gangrene in a wound calls for the immediate adoption of even more energetic and thorough antiseptic methods of treatment than have been prescribed in the preceding paragraphs. All loose gangrenous tissue should be removed at once with knife and scissors, and the living tissues exposed should be freely and thoroughly cauterized by an 8 per cent. chloride-of-zinc solution, which should be injected into every cavity and recess of the wound. Free incisions and counter-incisions should be made into the swollen and infiltrated tissues leading from the gangrenous focus, so as to permit the escape of secretions and débris and to enable the disinfecting liquid to reach every infected part. The wound should be left uncovered, and continuous irrigation with an antiseptic solution established. For such irrigating liquid a 1 per cent. solution of carbolic acid or of acetate of aluminium or a 1 : 15,000 sublimate solution may be used. The antiseptic irrigation should be continued until permanent arrest of the gangrenous process is manifest, all necrotic tissues have come away, and a healthy granulating surface has formed.

ERYSIPELAS.—The appearance of erysipelas is always due to some defect or neglect in the antiseptic precautions. It is always of specific septic origin, and it most especially calls for that method of treatment adapted to septic wounds. (For a full consideration of this subject see Erysipelas.)

SUPPURATION.—The occurrence of suppuration in a wound makes it necessary that full provision should at once be made for the easy and perfect escape of the pus. This has already been considered in what has been said in regard to drainage. Some further thought, however, should be given to the management of a suppurating wound, with a view to the restriction of the process of suppuration and the hastening of the healing of the wound as much as possible. When the wound is shallow and widely open, and not too extensive, iodoform gauze may be applied upon its whole surface as a dressing, and will diminish greatly the amount of pus secreted and stimulate the granulating process. The final healing may then be accelerated by the application of a secondary suture

when possible or the employment of skin-grafts. When the suppurating cavity is deep or tortuous, or its external opening is comparatively small, antiseptic irrigations are of value. Care should be taken in the use of all such irrigations not to inject the fluid with so much force as to break up adhesions already formed. Care must also be taken that the possibly poisonous antiseptic be not retained in the wound. This is best accomplished by finally flushing the wound with warm boiled water to wash away the antiseptic solution. Injecting a fresh solution of peroxide of hydrogen into a suppurating wound answers the same purpose, and is an efficient means of decomposing any retained pus and of sterilizing the wound-cavity. Solutions of bichloride of mercury, 1 : 2000, of carbolic acid, 2 per cent., or of boro-salicylic acid in saturated solution, are also efficient. When, notwithstanding the use of these means, the granulating process remains sluggish and the wound-cavities delay in contracting and healing, more strongly stimulating applications are indicated. Naphthalin in powder freely sprinkled over the sluggish surface, or the balsams of Peru or of copaiba freely instilled, or tampons of gauze saturated with these agents, may be used. If these are not efficient, superficial cauterizing agents, such as carbolic acid of full strength, fused nitrate of silver, or an 8 per cent. solution of chloride of zinc may be used. In all these cases constant attention should be paid to keeping the deeper parts of the wound-cavities in apposition by properly-applied pressure, and to securing absolute rest for the injured parts. Especial care must be taken that the external dressings that are applied are such as will freely absorb the pus which is brought to the surface. Nothing will more aggravate the condition of a suppurating wound than a dressing that dams back and causes retention of its secretions. Viscid pus is not absorbed to any great degree by the ordinary cotton dressings, and if they are used they must be frequently removed and the wound cleansed. In ordinary pine sawdust of moderate coarseness the surgeon will always find an easily obtainable substance which absorbs pus freely. It can be made aseptic by baking, and then antiseptic by wetting with a sublimate solution. This sawdust made into convenient-sized pads by enclosing in any thin gauzy stuff, like cheese-cloth, may be used as a dressing, with a certainty that retention will not be caused by it, so that infrequent dressing may be the rule even in such wounds.

When by any of the means described a vigorous granulating surface has been obtained and the case is not suitable for secondary suture or skin-grafting, the further treatment of the granulating surface must be one of protection while the gradual process of cicatrization by extension of the cuticle from the edges is going on. Bland or mildly stimulating ointments spread on soft antiseptic dressings of some kind are commonly used for this purpose. Suitable material for such ointments are the simple cerate of the Pharmacopeia, oxide-of-zinc ointment with which a little carbolic acid has been incorporated (f3ss to 3j), boric-acid ointment 15 per cent., iodoform with a petroleum basis, such as carbolated cosmoline (3j to 3j), make invaluable applications to such surfaces, and should be employed by preference when the wound is near a mucous outlet or other possible source of infection. An efficient protection, and one even more cleanly and in harmony with ideal asepsis, is to be found in strips of rubber gauze or in the fine oiled-silk material known as "protective." These should be sterilized by immersion in a carbolic or bichloride lotion of suitable strength for some time before they are used, and when applied upon a granulating surface which has previously been sterilized, and then covered by a suitable antiseptic absorbent dressing, the whole forms an ideal dressing for a granulating surface. Whenever the granulating surface is of any size, resort should be had to skin-grafting for the purpose of hastening its cicatrization

whenever practicable. This is a most valuable means for shortening the period of cure in cases of open wounds, and deserves to be frequently used by surgeons. (For the technique of skin-grafting see the chapter on Plastic Surgery.)

INCISED WOUNDS.

By incised wounds are meant those clean-cut divisions of tissue which are produced by the edges of a sharp instrument. They may vary in size from the most trivial to formidable and deep incisions of many inches in length—from a superficial scratch to wounds opening deep cavities or almost severing entire members from the body. Their surfaces present in a minimum degree an imperceptible layer of devitalized tissue destroyed by the impact of the cutting instrument, tissue, which is quickly removed in the early stages of normal repair and produces no disturbance in the healing of the wound. For this reason they present conditions most favorable for speedy healing, and deserve from the surgeon careful attention to all the details of cleansing, apposition, and rest which have been described in previous pages, so that primary union may be obtained.

Symptoms.—Pain resulting from an incised wound is severe and sharp at the moment of its infliction, subsiding into a smarting or burning which persists for some time; hemorrhage is free, and the gaping of the tissues is restrained only by the limits of the contractility of the tissues divided.

Treatment.—In the arrest of hemorrhage, which in general will be accomplished with but little difficulty, care must be taken to avoid any means or agents which could later prove a source of disturbance in the healing process. The use of all styptic agents should be especially avoided. Bleeding from all but vessels of considerable size will be arrested by temporary pressure, by exposure to the air, or by the application of hot water aided by compression. The mutual pressure of the wound-surfaces against each other after they have been brought into apposition serves to restrain any tendency to further hemorrhage. When large blood-vessels are wounded ligatures are required; wounds involving such vessels are most dangerous, and may quickly terminate fatally from loss of blood, so that the most energetic and instant resort to measures for the arrest of hemorrhage is called for in such cases. When a vessel is but partially divided, it is more difficult to stay the bleeding from it than if it is cut through entirely. In such cases the first thing to be done is to complete the division of the vessel, ligating it later if necessary.

The drainage of incised wounds, when with proper care their deeper parts can be maintained in apposition, is very simple. In the more extensive wounds capillary drains or small tubular drains during the first twenty-four or thirty-six hours will suffice. In a large proportion of cases where compression and immobilization of the part can be effected no provision for drainage is required. The apposition of the wounded surfaces should be attended to with the utmost care and minuteness, so that, by the use of sutures, compresses, bandages, and position, coaptation of every part should be perfect and no spaces be left for the collection of secretions. The protective dressings required by incised wounds the coaptation of the surfaces of which is possible are very simple. Exposure of the line of suture to the air, so that the desiccation of the slight amount of secretion that gathers there may form a protective crust, gives excellent results when the conditions of the wound are such as to make it practicable. A light, dry, clean absorbent dressing of some kind is all that is required at any time. The provisions for rest in the case of incised wounds may and should be made absolute by splints. The removal and readjustment of

dressing should be long deferred. The ideal to be aimed at is perfect healing without local discomfort or constitutional disturbance under a single dressing.

LACERATED AND CONTUSED WOUNDS.

A lacerated wound is one in which the tissues have been forcibly torn asunder; a contused wound, one in which the wounding force has been of a crushing character. In many instances both the lacerating and crushing elements are mingled. In any case the character and course of both classes of wounds are similar, so that they may properly be considered together. The surface of such wounds is irregular, shreddy, possibly presenting long dangling strips of fibrous and tendinous tissue, with more or less blood-clot filling the exposed cavities, and with a variable amount of dead or partially disorganized tissue scattered upon its surface. The skin-wound is irregularly torn, less in extent than the wounds of the deeper structures, from which it is more or less separated, while its borders present an area of variable dimensions that is livid and cold, ready to fall into necrosis. The great increase in the use of machinery in modern times, and of rapidly-moving and heavy vehicles operated by steam, electric, and horse-power, has vastly multiplied the frequency of lacerated and contused wounds.

Such wounds produce greater shock than do incised wounds, but are accompanied by less appreciable pain. The pain is dull and aching in character; the hemorrhage is generally slight, owing to the surface irregularity that favors the coagulation of the blood flowing over it, and to the fact that the larger blood-vessels have had their coats so irregularly torn that an occlusive clot is at once formed in the torn ends. The tissue-interspaces for some distance from the wound-opening become infiltrated with diffused and clotted blood, and in many instances foreign material, dirt of every conceivable character, is ground into the wound-surfaces, so as to defy every effort to remove it entirely. In cases of severe injury of this kind the partial syncope resulting from shock so diminishes the force of the circulation as also materially to lessen the tendency to hemorrhage. Although for these reasons primary hemorrhage is generally slight, serious later hemorrhage is not infrequent, either within a few hours, when the heart's action has regained its power and local reaction has set in ("intermediate" or "reactionary" or "consecutive" hemorrhage), or at a more distant period, when by the separation of sloughs the vessels are again opened ("secondary" hemorrhage). The external appearance of these wounds often gives no suggestion of the extent of the damage which has been done. They should therefore always be examined with great care, and the possibilities of far-extending subcutaneous injury should be kept in mind.

More or less death of tissue is inevitable in the after-course of such wounds. Some tissue, often much, is killed outright by the violence, while yet more is left in a seriously damaged state, prone to fall into necrosis from the defective nutrition that for a time exists in the part. Much of the abundant and irregularly diffused blood-clot which is present will subsequently disintegrate and liquefy. When, with greater or less rapidity according to the activity of the nutritive processes in the part, all necrotic tissue has separated and been removed, and the blood-clot has either been absorbed or has broken down and escaped, there remains behind a uniform granulating surface, and the further course of the wound is toward healing by granulation.

All the conditions presented by these wounds are such as to render them specially liable to septic infection of serious character.

Treatment.—Although there may be but little hemorrhage at the time of

the first dressing of a lacerated or contused wound, yet if vessels of any size have been torn it is the part of wisdom to apply ligatures to them, though they may not be bleeding at the time. The period of reaction from shock is to be watched with especial care to guard against possible hemorrhage. Should this hemorrhage at any time occur, the application of a ligature is imperative, even though the bleeding may have ceased spontaneously as the heart's action is weakened; for so soon as the reaction again comes on and the heart beats strongly once more, the hemorrhage will surely recur. The primary cleansing of the wound should be conducted with great care by rubbing sweet oil thoroughly over the surface, including the adjacent skin, then cleansing by soap and warm water well scrubbed on, following this by washing with alcohol, and finally by thorough scrubbing with sublimate solution, 1:1000. All detached particles of bone and of the soft parts should be carefully removed, and tissues into which foreign matter has been so ground that the complete removal of the dirt is impossible should be trimmed away with scissors or knife. Bruised portions of tissue that are still attached should be carefully cleansed and replaced and preserved from further traumatism, since much that appears to be hopelessly destroyed may be saved in many cases by care in fostering its nutrition. Thorough scrubbing and irrigation of a contused and lacerated wound with a warm antiseptic lotion until no element of sepsis is left within it is important, for all the conditions of these wounds are such as to create and present to a large degree the material favorable for the rank development of septic organisms. The natural resisting power of the tissues, which enables the surfaces exposed in ordinary incised wounds to resist the development of sepsis and to preserve the minute devitalized fragments of tissue that are present from undergoing putrefaction, is no longer to be relied on, for the bruised wound-surfaces have to struggle to retain their own vitality, and large masses of devitalized tissue and more copious effusions of putrefiable secretions have to be disposed of.

The fullest provision must be made for drainage from all the recesses of the wound. Free counter-incisions must be made wherever necessary for this purpose. Efforts at accomplishing apposition of the wound-surfaces must be subordinated to the need for drainage and the provision for the unhindered separation of necrotic tissue. In cases of severe contusion a degree of uncertainty will always exist as to the ability of the injured tissue to retain its vitality, and a certain amount of necrosis is to be expected and provided for. This necrosis will be reduced to a minimum in proportion as the provisions for making and keeping the wound aseptic are thorough and successful. When adequate antiseptic measures are practicable, greater efforts at securing coaptation of the wound-surfaces are proper. Special care should be observed to avoid all tension of the wounded tissues in the endeavor to approximate them. In a large proportion of contused and lacerated wounds there will be such an amount of destruction of tissue that any attempt at closing them to secure primary union will be manifestly contraindicated. In such cases the efforts of the surgeon should be chiefly directed toward protecting the wound from sources of disturbance during the time that the separation of the sloughs and the process of granulation are going on. These are the cases in which local septic inflammations, gangrene, erysipelas, and general septic infection are most prone to occur. The manner in which such disturbances are to be met has been fully discussed in preceding pages. While the constitutional symptoms produced by them will often require special treatment, they will spontaneously subside if adequate local antiseptic measures are employed. The latter, therefore, should always engage the first and most constant attention of the surgeon.

BRUSH BURN.—By this term is meant a peculiar form of superficial lacerated and contused wound caused by friction applied to the surface of the body, as when a portion of skin is brought into contact with a rapidly-moving belt of machinery, or by an involuntary slide down a steep incline, or by the slipping of a rope through the closed hand. In this injury the superficial tissues are ground off and an eschar of considerable depth results. They should be treated by antiseptic fomentations until the eschar has separated and a granulating surface has formed, which should then receive the treatment elsewhere described.

PUNCTURED WOUNDS.

Deeply perforating wounds made by pointed substances will partake of the nature of either incised or contused and lacerated wounds, according to the sharpness of the point of the wounding instrument. Punctured wounds made with sharp, clean-pointed instruments, as pins, needles, trocars, dagger and stiletto points, partake of the nature of limited incised wounds, and unless in their course they have wounded organs of importance, as large blood-vessels or nerves, the withdrawal of the instrument is followed by rapid and perfect recovery. Should the puncturing instrument, however, be contaminated with active septic material, an acute septic inflammation will result, depending upon its depth from the surface for its importance, and demanding free incisions for the relief of the pent-up secretions. For its further care those measures which have been described as required for inflamed and infected incised wounds will be indicated. Punctured wounds which are formed by the thrusting into the tissues of irregularly-shaped and blunt substances, such as splinters of wood, nails, a bayonet, and the like, form deep and narrow wound-tracks, the walls of which are contused and lacerated, while minute fragments of devitalized tissues or small fragments of infected material are driven in and deposited in the depths of the wound. The dangers and difficulties attending ordinary contused and lacerated wounds are aggravated in these cases by the long and narrow track which leads from their bottom to the surface. Should no septic material have been introduced by the wounding body, such wounds may yet be expected to heal kindly and promptly if care is taken to avoid their subsequent infection from without and to keep the wounded part at rest while repair is taking place. In view of the impossibility of adequately disinfecting such a wound by mere applications to the surface at the time of the dressing, as a general rule it should be freely laid open to the bottom by additional incisions, and there should be thorough disinfection of the wound and the adjacent integument. It should then be covered with an abundant antiseptic dressing, which should be supplemented by any posture or by the application of whatever apparatus that may be required to keep the part at rest. If, notwithstanding this, inflammation of the deeper part of the wound develops, immediate resort should be had to additional free incisions to give vent to pent-up effusions and for subsequent disinfection and drainage. The more deep and narrow the wound-track, the more important that free and early incisions should be made. Still more important, if possible, are such early incisions when the puncture has involved strong fasciæ, the thecæ of tendons, or joint-cavities. Delay in resorting to such incisions is not only sure to produce extensive local damage, but may even prove dangerous to life.

Not infrequently portions of puncturing bodies are broken off and left imbedded in the tissues. In some cases such imbedded substances may remain innocuous for an indefinite period of time. In yet other instances their presence provokes irritative symptoms of a marked character. Foreign

bodies in the neighborhood of joints, or piercing nerves, tendons, or blood-vessels, are sure to be followed by excessive pain, muscular spasm, or hemorrhage. Diligent effort should be made to detect and remove foreign bodies at the bottom of punctured wounds whenever there is reason to suppose from the nature of the body or the nature of the tissues wounded that they will become a source of peril or discomfort if allowed to remain, or in any case when the conditions are favorable to making such a search without an unduly extended or dangerous dissection. The instrument inflicting the wound should always be inspected to determine whether any of it has been broken off and left in the tissues. For the removal of such bodies the enlargement of the original wound may suffice, or possibly counter-openings at distant points may be required, so as to give more ready access to the body sought for. Such counter-openings may be of additional value in providing means for thorough drainage. In attempting the removal of minute bodies, such as the fragment of a needle or a small bit of glass, the search may often be facilitated by raising a triangular flap in the centre of the base of which is the original point of puncture, the apex of the flap lying in the direction toward which the body has penetrated. This flap should include the skin and superficial fascia, and when raised gives more easy access to the deeper tissues, and permits a more free and thorough search for any small body which may be imbedded among them. To make such an operation bloodless, Es-march's bandage is often of the greatest use. The removal of a puncturing body when it projects from the surface, or lies so near the surface that it can be readily seized, is usually easy, but in some cases, by reason of the irregularity of its surface or its being barbed, as a fish-hook or arrow-head, its removal is difficult. Whenever the location of such an entangled body permits it to be easily pushed through to the other side, such a course should be adopted. When this manœuvre is not feasible, whatever incisions may be required to free the body from entanglement and allow it to be easily plucked out should be made.

The hemorrhage in punctured wounds is usually slight and requires no special attention. Should it be at all free, the possibility of the wounding of a large vessel should suggest itself, and a careful review of the anatomical relations of the puncture should be made. Should the hemorrhage not be easily controlled by pressure, the wound should be enlarged, the bleeding point identified, and a ligature applied. A false aneurysm is the not infrequent result of partial divisions of arteries in punctured wounds. Punctured wounds impaling a vein and an artery lying in contact with each other are occasionally the cause of arterio-venous aneurysms. Such sequelæ call in many cases for free incisions and for exposure of the wounded vessels and ligature above and below the point of wound.

GUNSHOT WOUNDS.

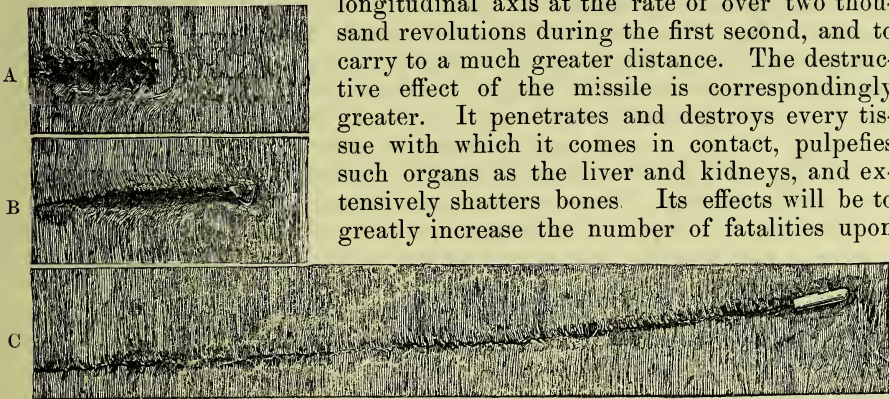
The term "gunshot wound" is applied generically to injuries inflicted by missiles, whatever their character, whose force is derived from the explosive power of gunpowder. This definition, therefore, includes every grade of missile, from the smallest bird shot to the immense projectile fired from mammoth pieces of heavy ordnance, and every grade of injury, from the mere peppering of the surface of the skin with grains of gunpowder or minute shot to the laceration and comminution of extensive portions of the body.

The character of the injury produced when the missile has penetrated the tissues, which is usually the case, is that of a contused, lacerated, punctured wound; when the surface is merely grazed, it partakes of the nature of the

brush burn, as already described. In occasional instances a large missile moving with slight momentum fails to break the skin, but produces extensive damage to the subcutaneous tissue. The missiles which are more frequently met with in gunshot wounds are (a) the shot used in fowling-pieces, which are of various sizes, from that of a buck shot, which weighs 133 grains, to that of the smallest bird shot, one of which weighs only $\frac{1}{5}$ of a grain; (b) pistol bullets, varying in size from about $\frac{1}{8}$ of an inch to $\frac{1}{2}$ of an inch in diameter, and weighing from 20 grains to 240 grains. The size of a pistol bullet is usually designated according to the decimal part of an inch which makes its diameter; thus a 22-caliber bullet is one whose diameter is 22-hundredths of an inch. (c) The rifle bullet, which is the missile of the modern arm of precision, long and generally conoidal, and weighing from $\frac{3}{4}$ to $1\frac{1}{2}$ ounces. For military use yet larger missiles have been devised which hardly arrive at the dignity of cannon shot, and yet are heavier than the rifle balls of the infantryman, such as the projectiles thrown by the mitrailleuse, Gatling, and Hotchkiss guns.

The Männlicher rifle, which is now coming into general use as a military weapon, projects a bullet of small caliber (.25-.32 caliber; 6.5 to 8 millimeters in diameter), which, by the use of cellulose powder, shells of cupro-nickeled steel, and a more abrupt rifling, is driven with greatly increased velocity, and made to revolve upon its longitudinal axis at the rate of over two thousand revolutions during the first second, and to carry to a much greater distance. The destructive effect of the missile is correspondingly greater. It penetrates and destroys every tissue with which it comes in contact, pulpefies such organs as the liver and kidneys, and extensively shatters bones. Its effects will be to greatly increase the number of fatalities upon

FIG. 20.



Relative Penetration of Bullets across the Grain of Oak, showing their deformation: A, ordinary .45-caliber lead bullet (powder, 69 gr., penetration, 3.2 in.); B, new .30-caliber German-silver-jacketed bullet (powder, 37 gr., penetration, 5.3 in.); C, cupro-nickeled-steel-jacketed .30-caliber bullet (powder, 37 gr., penetration, 19.5 in.).

the battle-field, both by the larger number of men injured by a single bullet and by the necessary removal to a far greater distance from the battle-field of the field hospital, so as to be beyond the range of the firing. Figure 20 shows (A) the relative penetration in oak, across the grain, of the .45-caliber lead bullet and the great deformation of the ball; (B), the .30-caliber German-silver-jacketed bullet and its deformation; and (C), the .30-caliber cupro-nickeled-steel-jacketed bullet, which still retained its original form.

The repair of gunshot wounds is often disturbed by foreign matter carried into the wound by the projectile, such as portions of clothing, gun-wadding, buttons, pieces of coin, splinters of wood, etc. The mere explosion of powder from a gun fired at short range may produce a serious injury which combines the characters of a burn with those of contusion and laceration.

Gunshot wounds derive especial significance from—1. The special tissue or organ injured; 2. The conditions under which the wound was inflicted; 3. The presence or absence of septic infection.

INJURIES TO SPECIAL TISSUES.—*The Skin.*—The effects of grazing the skin and of contusion without penetration have already been referred to. When a penetrating wound has been inflicted, the wound of entrance is generally small and less in diameter than that of the missile itself, owing to the elasticity of the skin, which has been stretched by the ball before being penetrated by it. It is also apt to be dirty, both from the powder if the wound was at short range, and from wiping the dirt from the ball as it enters. Such a wound will appear insignificant to one unfamiliar with its real gravity. Should other foreign matter be carried in with the ball, the wound of entrance will be correspondingly increased in size. Should the ball pass clear through the body or limb, the wound of exit will be larger and more ragged than that of entrance, the difference being determined by the lessened momentum of the ball and the want of support to the tissues at the point of exit, as a nail driven through a board splinters largely the under side or point of exit. Conical bullets, having greater penetrating power than round, produce in the skin-wounds which they make much less difference in size than formerly resulted from the use of round bullets. By subsequent sloughing of the contused margins of the wound of entrance it often becomes after a few days of greater magnitude than that of exit.

Fasciæ.—Especial interest attending wounds of fasciæ arises from the fact that their interlacing fibers are often to a considerable degree split and crowded aside by the ball as it passes through them, so that the orifice that they present is much less free than is found in the softer tissues on either side, and tends to interfere materially with the drainage of the deeper parts of the wound. Dense fasciæ again frequently present sufficient resistance to a ball, especially if it is a round one, to deflect it from its original course.

Muscles when involved are subjected to widespread damage through contusion and laceration of their substance and extensive infiltrations of blood.

Tendons, by reason of the resisting nature of their structure and their roundness and mobility, are more frequently either pushed out of the way or deflect the bullet.

Blood-vessels, especially arteries, whose walls are more resistant and elastic than those of veins, are not infrequently pushed aside. Even in such cases, however, such contusion of their structure is often inflicted as to determine subsequent sloughing and secondary hemorrhage. Both partial and complete division of large blood-vessels is a frequent concomitant of gunshot wounds, and is also the most frequent cause of immediate death by reason of the hemorrhage following. Traumatic aneurysm and arterio-venous aneurysm may result in certain cases, as has already been noted in ordinary punctured wounds.

Nerves.—Large nerve-trunks when wounded present no special symptoms that call for extended notice here. The functional disability resulting from such wounds will depend upon the special function of the particular nerve, and may be more or less complex and important. Severe pain may result primarily from inflammatory processes in the injured nerve, or later from its being involved in a contracting cicatrix or by development upon its end of a neuroma. Trophic changes of every degree are among the ultimate results of nerve-injuries. (See Injuries of Nerves.)

Bones.—A ball striking upon a bone usually inflicts much damage upon it, splitting and comminuting it, often producing fissures that extend into neighboring joints. The bullet may become lodged in the bone, remaining as a source of irritation, and often of suppurative inflammation, until removed.

The Great Cavities of the Body.—Balls penetrating the cranial cavity will produce symptoms according to the region of the brain injured; though always

serious, the wounds they inflict are not necessarily fatal. Penetrating wounds of the thorax may involve the lungs, the heart, or the great vessels, and, if not immediately fatal, present special difficulties in the inflammatory complications or in the resulting extensive pleural or pericardial effusions. Penetrating wounds of the abdominal cavity, in addition to the dangers from hemorrhage and from ordinary inflammatory complications, have the special dangers incident to possible wounds of the stomach, intestines, bladder, and the various other abdominal viscera. (See Wounds of the Abdomen and its Viscera.)

THE CONDITIONS UNDER WHICH THE WOUND IS INFLICTED.—Gunshot wounds differ especially from the ordinary operative wounds inflicted by a surgeon in the special conditions incident to warfare which make it difficult, often impossible, to give to the patients the full degree of care which they require, and which often expose them to further injury that greatly aggravates the original severity of the wounds. In dealing with these conditions is found the special field of military surgery. In civil life, however, it often happens that gunshot wounds are sustained under conditions that resemble those of military campaigning, as in the case of accidental wounds occurring among hunting-parties in regions remote from help. The frequent absence of skilled help and of the materials for the proper dressings for such wounds adds greatly to the dangers which attend them. The necessary transportation of wounded men for long distances, often with the most crude resources for their comfort, is another fruitful source of evil, and has many times demanded the sacrifice of a limb or has occasioned the loss of a life which under more favorable circumstances could have been saved. In the accidental gunshot wounds of civil life also it is by no means the rule that adequate surgical skill and proper dressing materials are at once attainable.

THE PRESENCE OR ABSENCE OF SEPTIC INFECTION.—This is a factor of the highest importance in determining the favorable or unfavorable course of a gunshot wound. If such a wound is preserved from septic infection, the wound of entrance is quickly closed and its remaining track, however long it may be, or however much lined by contused necrotic tissue, or whatever organ it may have traversed or bones it may have shattered, is reduced to the condition of a subcutaneous injury, and is thereby saved from a thousand dangers that might otherwise complicate its healing. Fortunately, experience has shown that in many instances a penetrating bullet does not carry with it septic material, and that if a wound which has been thus made is preserved from subsequent infection, an aseptic course of healing will take place. The question of the removal of the bullet itself in such cases becomes a secondary matter, depending entirely upon the importance of the later symptoms of disturbance which its presence in the tissues might occasion. On the other hand, the introduction of sepsis into a gunshot wound is sure to determine inflammatory and suppurative symptoms of the most pronounced type, and to call for the most energetic and thorough interference on the part of the surgeon. Secondary hemorrhages are to be feared; necrotic debris and the pent-up products of septic inflammation will require to be evacuated; increased dangers to life and limb will be incurred; and in the most favorable event a prolonged convalescence will result.

Diagnosis.—The circumstances attending the infliction of a gunshot wound will usually be sufficiently clear to settle the fact that a given wound is due to the penetration of the tissues by a projectile driven by the explosive force of gunpowder; but the surgeon in investigating the case may find it important to determine the course which the missile has taken, the organs injured, and the final resting-place of the missile, provided it has not already escaped by an aperture of exit. The external marks of injury may

give no clue whatever to the character and extent of the deeper injuries which have been received. In forming any conclusion as to the extent and nature of the wound which has been received, a careful investigation, therefore, must be made into all the symptoms attending the injury, such as shock, hemorrhage, functional disturbance, local pain, and tenderness, as well as an inspection of the external signs of wounding. All such investigations should be made with the most scrupulous care to avoid touching the wound itself unless under the most rigid antiseptic precautions. When it is possible to ascertain the direction from which the missile came and the position of the body or limb at the time the wound was received, valuable information as to the course which the missile has taken through the tissues may sometimes be gained by putting the parts again into the same position. The possible deflection of the bullet by bone or fasciæ is not to be forgotten, and must be given due weight in explaining otherwise confusing symptoms. The slight differences which have already been remarked upon as existing between the orifices of entrance and exit should be borne in mind in determining the point of primary penetration when two apertures exist. The amount of pain attending the reception of a gunshot wound varies much, and is of little value as a diagnostic symptom. In the excitement of the moment many wounds are received with no consciousness of the fact on the part of the injured person, who discovers it later only through the hemorrhage or the functional disability which results. In other cases a sharp stinging pain or a dull, numb sensation indicates to the person that he has been wounded. Sometimes the shock of even slight wounds is very great.

Probing a Wound.—When the circumstances of the case or the symptoms which are present make it important that the deeper recesses of the wound should be searched, this is to be accomplished by the insertion of the finger of the surgeon if possible, or by the use of suitable probes, and all the steps of the process of search should be conducted with most careful regard to the requirements of rigid antisepsis. Such probings are not to be done as a matter of routine, but only when some distinct indication is present. Free enlargement of the external wound should be made without hesitation whenever it will facilitate the prosecution of the search, and as far as possible reliance should be placed upon the finger of the surgeon for gaining the desired information to the exclusion of metallic or other probes. When it is necessary to pursue the investigation into depths which are beyond the reach of the finger, a metallic probe of suitable length and having a bulbous tip of considerable size may be used. Such a probe having the tip made of porcelain biscuit, and known as Nélaton's probe, has the special value that when the tip comes in contact with the bullet at the bottom of the wound it retains the mark of the lead upon it, and thus gives an absolute demonstration that it has been in contact with the bullet or a fragment of it. Before using it its freedom from any similar prior stain must be ascertained. The stem of an ordinary clay pipe has been used extemporaneously for the same purpose. The "telephonic probe" of Girdner is an ingenious application of the telephone which may occasionally assist in identifying the location of a bullet in the tissues. This device may be extemporized whenever an ordinary telephone receiver is accessible: one of the wires of the telephone having been attached to the probe, the other is made fast to a metallic plate, which is placed upon any portion of the surface of the body previously moistened. The probe is now inserted into the wound for the purpose of the search, while the telephone receiver is held to the ear of an assistant; whenever the probe comes in contact with the bullet a distinct click is heard in the telephone—a click which is not elicited except by contact

with metal. Other methods for utilizing the electric current for detecting and locating a bullet imbedded in the tissues have been devised; some of these are ingenious and successful as experiments, but none are susceptible of being utilized in general practice.

Probing should be done with gentleness and care. It cannot be too strongly impressed on the mind of the surgeon that all probing should be abstained from until such time as the final, thorough examination and dressing of the wound can be done, when once for all the probe may be resorted to in accordance with the restricted indications for its use hereafter mentioned.

Treatment.—Shock is to be combated in accordance with general principles. Persistent hemorrhage of sufficient extent to require special interference for its arrest indicates a wound of a vessel of considerable size. In such cases the rule is imperative to enlarge the wound sufficiently to expose freely the bleeding vessel and to ligate it upon both the proximal and distal sides. Should the vessel not have already been completely severed by the ball, it should be divided between the ligatures after their application. Hemorrhage occurring secondarily during the after-history of the wound demands the same treatment, and often involves an extensive dissection in the necrotic tissue. When, by reason of its anatomical position or the difficulty of finding it in the sloughing tissues, it is not practicable to expose the wounded vessel in this way, ligation of the main artery of supply in its continuity must be resorted to, but only after a determined effort has been made to ligate it in the wound itself.

From the standpoint of treatment gunshot wounds are divisible into two classes—first, those which are capable of primary occlusion of the external wound and of conversion into practically subcutaneous wounds; and secondly, those which must be treated as open wounds throughout. A large proportion of gunshot wounds are capable of being kept within the first of these two classes.

First class.—The first effort of the surgeon, therefore, should always be scrupulously to protect the wound from contamination from without. The one exception to this rule is found when necessity for interference for the arrest of hemorrhage is so great that its urgency may compel the disregard of every other precaution. The external wound may be of such extent as to be manifestly incapable of being sealed up by primary occlusion, but such a condition gives no warrant for the neglect of every possible effort at antisepsis from the beginning. The mere lodgment of a bullet in the tissues is not of itself an indication for the introduction of an exploring finger or probe, nor is it justifiable to disturb the wound by the new traumatism of an exploration until distinct evidence has appeared that the missile is seriously interfering with the repair of the wound by its presence, or unless there is good reason to believe that there has been carried into the wound with the bullet septic material, such as fragments of clothing. That exploration of a gunshot wound which is called for by reason of such manifest extensive laceration and destruction of tissue that the questions of excision and amputation require to be decided, is of an entirely different character from that which has as its end the quest for a bullet and its removal. Such explorations are made on general surgical principles, and become a part of the more formal and extensive operative procedures to which they lead. It is not infrequent, in cases where the foreign body has been allowed to remain undisturbed in its new position among the tissues, and satisfactory and rapid healing of the original wound has been secured, that the body subsequently becomes a source of irritation, so that its extraction is necessitated. A late operation of this kind, when it can be surrounded by every precaution, and is done among tissues which are no longer infiltrated and from which all

bloody extravasation has long been absorbed, is attended with much less danger than a primary operation would have been.

A gunshot wound from the time that it is received until adequate antiseptic cleansing and dressings can be applied should be left exposed to the air without any covering whatever, inasmuch as the air is less likely to be septic than any ordinary dressing which could be applied. By such exposure desiccation of the secretions about the wound-aperture is favored and a protective crust is formed. As early as possible after the infliction of the wound the external aperture and the surrounding area of skin for a number of inches should be thoroughly cleansed with soap and water and sterilized by the free application of a solution of corrosive sublimate, 1 : 1000, or of carbolic acid, 1 : 30. It should then be covered with an abundant dressing of absorbent antiseptic material. Almost anywhere ordinary linen or other similar dressings can be used after being made aseptic by heating in an oven to a point just short of burning. The wound-opening itself should by preference be covered by a bit of oiled silk or rubber protective previously sterilized, but this is not absolutely essential; the part should now be immobilized, if it is a limb that has been injured, by an adequate splint, which should extend sufficiently far above and below the wound to keep at rest all the muscular tissue of the part from origin to insertion. The wound should not be disturbed until definite healing has been accomplished, unless symptoms of septic infection should declare themselves, especially by a rise of temperature, thus converting the wound into one of the second class, next to be considered.

The second class of cases, which must be treated as open wounds, include those in which the extent of the wound is too great to give any hope from the first of securing its primary occlusion; those in which these attempts have been made, but have failed; and those in which such attempts have been deferred or omitted until the wound has become manifestly septic by reason of its exposure, its having been subjected to uncleanly and premature explorations, or the application to it of contaminated dressings. Even in this second class of cases all explorations and other operative measures should be deferred, if possible, until they can be done with the necessary disinfection, and can be accompanied by adequate protective dressing. Treatment should be conducted with scrupulous attention to the thorough disinfection of every accessible recess of the wound and to perfect freedom of drainage. The appearance of high fever, inflammatory swelling, progressive infiltration, gangrene, and other evidence of progressive septic contamination calls for the energetic and thorough application of all the resources for the control of sepsis which are within the command of the surgeon.

The primary examination and cleansing of the wound should be conducted with the view of making it aseptic if possible. Frequent partial cleansings should be avoided; repeated probings, cuttings, irrigations, and squeezing for the purpose of evacuating the wound-secretions and débris, which keep up a continued irritation of the wound, should be replaced by one thorough primary examination and cleansing. This should be conducted under an anesthetic, with deliberation and minute attention to the ultimate object in view—the destruction and prevention of sepsis. The external wound should be freely enlarged when necessary, so as to permit the introduction of a cleansed and disinfected finger for purposes of exploration. Bullets, splinters of bone entirely detached, pieces of clothing, and other foreign bodies which are found during the examination should be carefully extracted. A bullet, after having in the early part of its course inflicted injuries which require to be treated by the open method, not infrequently continues its course in such a manner that

the second part of its track may heal primarily behind it, and the bullet remain shut off from the first part of the wound, and there, becoming encysted, remain permanently without inducing further mischief.

The treatment of such a deep wound-track should be conducted on the same principles as those which control the more superficial wounds; it should not be probed nor irrigated, nor in any manner interfered with, unless evidences of inflammatory disturbances of its walls appear; no search should be made along it for the bullet; much less should the presence of the bullet at its bottom be considered an indication for an attempt at its removal, unless easily accessible from the opposite side, when it should be removed antiseptically. The disinfection and drainage of the superficial portion of the wound should be conducted with all care and thoroughness. Should deeper disturbances manifest themselves, the exploration, cleansing, and drainage of that portion of the wound would then be required. Enlargement of the aperture of communication with the superficial wound, and free counter-incisions to the extent required for its easy and perfect drainage and for the removal of any foreign and irritating bodies along its track, will be necessary.

A certain proportion of these injuries will require primary resections of joints, partial or complete, and amputations, as a part of the care required in the primary dressing. The necessity for these more important operative procedures will have become revealed in the course of the explorations which have been made. The judgment and experience of the surgeon as to his ability to ward off the dangers which threaten badly shattered joints and bones and extensively-mangled soft tissues, and to conduct the wound to a satisfactory healing so as to preserve a useful limb, must influence the decision in many cases as to whether a conservative method of treatment or the opposite should be adopted. In yet other cases, when, in addition to extensive injury to a bone or penetration of a joint, the main vessels or nerves of the limb are injured, or when extensive loss of the soft tissues has taken place, or when a part of the limb has been carried away, no alternative is left to the surgeon but amputation.

When the necessity of amputation is unquestionable, it should be done as soon after the shock from the primary wound has passed away as is practicable, provided this is before septic infection, inflammatory infiltration, and secondary traumatic fever have developed. This is the period characterized by old authors as the *primary period*; which, in pre-antiseptic days, extended over the first thirty-six to forty-eight hours. This is followed by a period extending over a variable time, during which there is progressive local inflammatory infiltration and general fever. This period is termed the *intermediary period*. During this period no operative interference is to be attempted other than that required for the removal of necrotic tissues or for affording adequate drainage, unless spreading gangrene of the wound develop, when distant amputation through tissues yet sound should be done as quickly as possible. When the primary inflammatory infiltration has become limited and begins to subside, and free suppuration from the wound-surfaces has become established, another period is said to have been reached, known as the *secondary period*. When the secondary period has been reached, amputation through tissues yet sound should be done without further delay.

The prolongation of the primary stage by antiseptic treatment—continuous antiseptic irrigation being the method which in general is best adapted to these cases—makes it possible for the surgeon to delay amputation until such time as, in his judgment, the patient will be in the most favorable condition to bear the operation. In some cases it will happily have served to demonstrate the possibility of recovery without amputation, for in not a few instances the

possibility of saving a limb will depend entirely upon the success of the efforts to prevent the wound from being invaded by septic infection. As soon as it is evident that these efforts have not been successful, amputation should be proceeded with, before the full local and constitutional symptoms of sepsis have developed.

Point of Amputation.—The choice of the point at which the amputation shall be made may be greatly influenced by the facilities at the command of the surgeon for keeping the wound aseptic. If these be adequate for the purpose, the section may be made at whatever point may be desirable to give the patient the most useful stump, even though bruised and lacerated parts be included in the flaps. These are preserved from inflammatory disturbance, their full vitality is regained, and they participate in the formation of the stump without disaster from sloughing. When, for any reason, the wound cannot receive adequate antiseptic treatment, amputation, if possible, should be made at a point sufficiently far above the injury to exclude all bruised and lacerated tissues from the flaps. A blind groping for a bullet at the bottom of a deep sinus should never be attempted. The enlargement of the external aperture and the dilatation of the deeper track, as required for the purposes of the cleansing and drainage of the wound or the counter-incisions made when the length of the track and the location of the ball demand it, should be ample enough to permit the sufficient exposure and ready seizure of the bullet if it is to be removed at all. For the purpose of facilitating the removal of a bullet when exposed many styles of forceps have been devised; it is not necessary that mention of any special one should be made. Any pair of forceps with slender and firm jaws, with slightly projecting teeth or with roughened points to increase the security of the grasp upon the bullet, will answer. The bullet will commonly be found to be somewhat battered and misshapen and entangled in interlacing strands of fibrous tissue that hold it closely, so that some little difficulty is often experienced in freeing the bullet so that it can be removed after it has once been exposed. If the bullet is firmly impacted in bone, it must be first loosened by the chisel or elevator, and then removed.

Gunpowder grains imbedded in the skin may be picked out by a sharp-pointed bistoury and a fine curette, or be left to spontaneous discharge by suppuration. In any event, a permanent tattooing will remain as a mark of the wound.

Arrow-wounds.—The wound made by an arrow is a punctured incised wound. Such wounds demand special mention only in connection with the question of the treatment of the arrow when any portion of it is lodged in the wound. The barbed head of the arrow, by becoming entangled in the tissues which close over it after it has penetrated them, forms a condition that is especially difficult to overcome if the arrow has penetrated to any depth. The general principles of surgery which are applicable to the search for and removal of all foreign bodies imbedded in the tissues are equally applicable to imbedded arrow-heads. If the shaft of the arrow is still attached to the head, it affords a valuable guide along which the dissection of the surgeon may be made for adequate exposure and disentanglement of the arrow-head. It should never be pulled upon for the purpose of removing the arrow, for the effort will certainly be futile, and if the shaft becomes separated from the head its further service as a guide is lost. If, however, the arrow has so far penetrated the tissues as to make it feasible to push it clear through and out on the other side, that treatment should be adopted; and in that case the shaft should be used to push out the head, the exit of which through the skin should be helped by the proper use of the knife. The head and the ribbon which attaches it to the shaft being

then removed, the shaft itself can be withdrawn. Arrow-heads do not become encysted like bullets. The experience of military surgeons is uniform that an arrow-head lodged in the soft tissues invariably produces serious results. Hence the rule is without exception that an arrow-head left behind and lodged in the tissues must be removed as soon as possible, even if this removal should require the severest and most dangerous operation (Bill).

POISONED WOUNDS.

Certain wounds remain to be considered which are associated with the inoculation of special hurtful substances. They have long been classed together as poisoned wounds, although in some the poison injected is of a chemical character, while in others it is microbic. A distinction, however, should be made between wounds that are subjected to microbic and those subjected to chemical influences. The former constitute the general class of infected wounds, in which are to be grouped not only all those heretofore described as subject to the usual septic infection, but also those which are infected by special microbes, as rabies, glanders, anthrax, actinomycosis, etc. Chemical poisons differ from microbic poisons in that they are incapable of self-reproduction, and that their deleterious effects are proportionate to the amount of the poison at first introduced into the body. In this class are to be grouped the bites and stings of insects and of reptiles. It is not to be overlooked that in ordinary infected wounds the local and general symptoms which are produced are due largely to the action of the chemical poisons or ptomaines which are generated by the micro-organisms that infest the wound, and not to the presence of the micro-organisms themselves. Such wounds are therefore of a double nature. In all cases where there is a tendency to spreading gangrene this mixed character of the poison is especially marked. The acrid ptomaine by its chemical effect upon the tissues with which it comes in contact produces their death and converts them into a fertile soil for the rapid multiplication of the invading micro-organisms, which, again, as they multiply, produce a renewed supply of the ptomaine, that attacks a fresh layer of tissue; and thus the vicious circle is completed and the progressively destructive process is maintained. There are, therefore, three great classes of poisoned wounds:

First, that of **mixed or bio-chemical infection**, which includes all the ordinary septic wounds that have been treated of in the preceding pages, and likewise those special wounds which are at times accompanied with marked tendencies to spreading inflammation and gangrene, such as those received in the dissecting-room, during post-mortem examinations, by butchers and fish-dealers from tainted meat and fish, and those resulting in that rapidly-extending gangrenous process known as "malignant œdema."

Second, **chemical poisons alone**—the bites of insects and reptiles.

Third, **microbic infection alone**—rabies, glanders, etc. This latter class differs so widely and materially in every respect from the first two as to deserve an entirely separate consideration. We shall accordingly group the first two under the one head of *Poisoned Wounds proper*, while the latter class we shall treat under the designation *Surgical Diseases due to Microbic Infection*. A number of these are usually derived from animals.

POISONED WOUNDS PROPER.

DISSECTION WOUNDS.—The term "dissection wounds" is applied to septic wounds of special virulence contracted in the dissection of dead bodies, both in

the dissecting-room and especially in post-mortem examinations. It is applicable also to a similar class of injuries sustained by surgeons in operating on the living; similar wounds occur also in butchers, fish-dealers, cooks, and other persons whose vocations may demand their handling putrefying animal material. Only a very small proportion of the pricks inflicted upon themselves by medical students and surgeons in dissecting the bodies of the dead or in operating upon the living are followed by any serious consequences. For the development of the more grave results it is necessary that there shall be some special virulence in the tissues or fluids by which the wound is inoculated, or that the individual who receives the wound should be in a condition of general constitutional depression, so that the natural resisting power of his tissues is greatly diminished. The worst cases occur when both these conditions happen to be combined. Experience has shown that the tissues of the recently dead are more frequently capable of communicating serious infection than those in which the process of decomposition is well advanced. The dissection of bodies in which death has been caused by virulent infective processes, as puerperal fever, erysipelas, or pyemia, is especially dangerous. Occasionally the wetting of the hands, on which there is no perceptible scratch or breach of surface, by the acrid fluids of a body dead of virulent infective disease may be attended with all the results for which the presence of a prick or scratch or abraded surface of some kind is usually necessary.

Symptoms.—The symptoms presented by a dissection wound may be those of any grade of septic infection, from that of slight local inflammation and suppuration to that of rapid, progressive gangrenous inflammation, with extreme general prostration from septic absorption, the development of pyemic foci in other parts of the body, and death. A not uncommon form is that in which the inflammation extends especially along the lymphatics, which appear as red lines, and produces marked swelling of the axillary glands.

Treatment.—The treatment of these wounds differs in no way from that which has been laid down for a septic wound in general. When an individual is conscious of the reception of the wound at the time, energetic local antiseptic treatment should be immediately instituted; thorough scrubbing and cleansing of the wound and the surrounding integument over a wide area should be made; the wound itself, if a puncture, should be enlarged sufficiently to permit of the certain introduction to its deepest point of the antiseptic to be used. The wound should then be thoroughly swabbed out with some such strong antiseptic agent as pure carbolic acid, solution of corrosive sublimate, 1 : 500, or solution of chloride of zinc, 8 per cent.; the part should be covered with an abundant dressing of absorbent material, which should be kept wet with a solution of corrosive sublimate, 1 : 2000, for three or four days; that is to say, until sufficient time has elapsed to demonstrate whether or not the disinfection of the wound has been successful. When this has been assured, any simple emollient protective dressing may be substituted until complete healing of the wound has taken place. When, through the neglect or inefficiency of primary antiseptic care, advancing phlegmonous inflammation or lymphatic irritation and glandular enlargement begin to develop, the surgeon should not wait until suppuration and sloughing of tissue have taken place before incising the inflamed and infiltrated regions, but should at once make sufficiently free incisions to open up thoroughly every infected district and to permit the free exit of the inflammatory secretions with which the tissues are infiltrated. The early resort to free incisions of this character will prevent much destruction of tissue and serious impairment of function, will relieve pain, and greatly abbreviate the course of the attack. Abundant antiseptic irrigations should be practised upon all the

tissue-spaces opened up by these incisions; the incisions themselves should be kept open by tents of iodoform gauze until all tendency to spreading inflammation has subsided and a healthy granulating process has developed. Meanwhile, the whole limb should be kept enveloped in wet bichloride dressings. Abscesses, whenever and wherever formed, should be opened as soon as possible and treated after the general manner already described. The constitutional treatment required will be conducted on general principles, and will include stimulants in large doses, opiates, and tonics.

MALIGNANT ŒDEMA, known also as *Gangrenous Emphysema* and *Gangrène Foudroyante*, is a rapidly-spreading gangrenous inflammation in which the affected tissues become distended with the gaseous products of decomposition, due to infection by a special micro-organism. (Pl. III, Fig. 1). This micro-organism was identified by Koch in 1882, and is a rod-like bacillus, resembling in form and size that of anthrax, but somewhat smaller, with rounded ends. The bacilli are joined together in threads after a peculiar fashion. Unlike the anthrax bacillus, they have the property of spontaneous motion and of spore-formation in the living body; they grow only in the absence of oxygen; they only rarely enter the animal body with any activity; they abound in garden soil, and may be met with in any kind of soil or dust. The gangrenous and putrefactive phenomena which are marked features of the disease in question are said not to be primarily produced by the bacillus, but to be due to the admixture with it of the ordinary putrefactive forms. According to Park (*Mütter Lectures on Surgical Pathology*, 1890 and 1891), when a pure culture of these specific bacilli is injected there results an extensive hemorrhagic œdema of the subcutaneous cellular tissue, without any appearance of putrefactive action and quite free from gas-formation; but when an impure culture is injected or when garden earth is used for inoculation, the distinctive œdema of the previous instance becomes a mixture of emphysemic œdema and gangrene. These organisms must be planted subcutaneously in the areolar tissues in order to produce the typical results. Inoculations upon abrasions or open wounds are harmless, owing to the free access of the inhibiting oxygen of the atmosphere.

Symptoms.—The local symptoms of the disease are those of a rapidly-extending gangrene surrounded by an extensive ever-spreading area of swollen, livid tissue, infiltrated by foul-smelling, acrid secretion and the gaseous products of decomposition. The œdematous tissues emit a fine crepitus when pressed by the finger; the overlying cuticle is raised into blebs filled with reddish offensive serum; the sloughing tissues are bathed in a thin putrid fluid. The general state of the patient is one of great prostration and profound septicemia, accompanied by apathy and sometimes by delirium. Death supervenes usually within from one to two days; after death putrefaction goes on with great rapidity. Examination of the viscera shows them to be congested and œdematous and the subject of multiple hemorrhagic infarcts.

The **diagnosis** of malignant œdema is simple. The clinical picture which it presents is clear and not likely to be mistaken for anything else. The first symptom is hemorrhagic œdema of the subcutaneous cellular tissue, to which is added infection with ordinary putrefactive organisms; a rapidly-spreading gangrene results, with the addition of an emphysemic element to the previously existing œdema from the gases of putrefaction. This mixture of emphysemic œdema and gangrene is the pathognomonic clinical feature of the disease. Microscopic examination of the œdema fluid will show numerous bacilli of the disease. The **prognosis** is always grave; with rare exceptions the disease marches rapidly to a fatal termination.

Treatment.—The treatment must be heroic and radical from the moment

of the recognition of the disease. If a limb is attacked, immediate amputation should be done at a point well above the line to which the disease has extended. When amputation is not feasible, a radical excision of the affected tissues should be done, with the most thorough, continuous, subsequent antiseptic treatment. The general strength should be sustained by vigorous stimulation and by other tonic and supporting treatment.

BITES AND STINGS OF INSECTS AND REPTILES.

These are minute punctured wounds into which has been injected some poisonous secretion from distinct poison-glands or from modified salivary glands of the animal inflicting the bite.

INSECT-BITES AND STINGS.—In the case of insects the poison inoculated is acid in its nature; the results of its injection present every degree of variation in severity, from that of the simple local irritation produced by the minor and more common insects, such as the flea, the mosquito, bedbug, various forms of mites, etc., to the greater local reaction and considerable constitutional disturbance following the stings of the more aggressive and venomous hymenoptera, such as bees, wasps, hornets, and yellow-jackets, and the still more virulent and dangerous centipedes, spiders, tarantulæ, and scorpions. As a rule, the stings of even the most venomous of insects are unattended with danger to life, but where many have been inflicted or when the person is weak and feeble severe constitutional disturbance, marked by chills, fever, and great prostration, and even ultimate death, may result, the severity of the symptoms depending upon the amount of the poison which has been absorbed into the general circulation. The wounds inflicted even by spiders and scorpions of the largest size rarely prove fatal.

Treatment.—Alkaline local applications should be used, such as dilute aqua ammoniæ or solution of bicarbonate of sodium. Ordinary loam mixed with water to form a mud poultice is useful as an extemporaneous application. Local inflammatory disturbances must be treated upon general principles; constitutional symptoms must also be combated according to the special indications of the particular case.

SERPENT-BITES.—In the United States naturalists have discovered twenty-seven species of poisonous serpents and one poisonous lizard; eighteen species of these are true rattlesnakes; the remaining are divided between varieties of the moccasin or copperhead and of the viper. The poisonous lizard is the Texan reptile known as the "Gila monster." In all these serpents the poison fluid is secreted in a gland which lies against the side of the skull below and behind the eye, from which a duct leads to the base of a hollow tooth or fang, one on each side of the upper jaw; which fang, except in the case of the vipers, is movable and susceptible of erection and depression. When not in use, the fang hugs the upper jaw and is ensheathed in a fold of mucous membrane. In the vipers the fang is permanently erect. In the act of biting the contents of the poison-sac are forcibly ejected through the hollow fang. In India venomous snakes abound, of which the chief are the hooded cobra, the viper, and the bungarus. In Europe the most dreaded serpent is the common viper, while Africa, South America, and Australia and the islands of the Pacific are not wanting in many varieties of venomous serpents. The physical appearances of all serpent-venom are nearly alike: it is a viscid fluid, varying in color from a pale amber to a deep yellow, and containing in solution certain albuminoid principles which are the toxic elements, the nature of which has not yet been made out. According to the researches of Mitchell and

Reichert, venom induces rapid necrotic changes in living tissues with which it is brought in contact. It renders the blood incoagulable, disintegrates the red blood-corpuscles, and produces such a change in the capillary blood-vessels that their walls are unable to resist the normal blood-pressure, and wide and rapid blood-extravasation results. Profound depression of the respiratory nerve-centers is the most common cause of death from serpent-venom, although cardiac paralysis, hemorrhages into the medulla, and general disorganization of the red blood-corpuscles may likewise each be a sufficient cause of death.

Symptoms.—Much similarity characterizes the effects which follow bites of all varieties of poisonous serpents. The amount of the venom injected and the rapidity with which it enters the circulation govern the intensity and the rapidity of the symptoms produced. The local symptoms are pain—at first slight, but later becoming more severe—with rapid tumefaction and ecchymotic discoloration in the vicinity of the wound. Symptoms of cardiac and respiratory depression soon manifest themselves by feeble and fluttering pulse, faintness, cold perspirations, mental distress, nausea and vomiting, and labored respiration. In the more intense cases of poisoning death may result in a short time by the paralyzing effect of the venom upon the heart, but more frequently the struggle extends over a number of hours. When life is prolonged over forty-eight hours, the special symptoms of venom-poisoning give place to those which are due to the disintegrating effect of the venom upon the blood and the tissues; that is to say, a sapremia of intense form remains, which may prove fatal by exhaustion or may be slowly recovered from. When death takes place from the primary effects of the venom, it is ushered in by delirium and coma, with intensification of all the primary symptoms.

The post-mortem appearances are those which would follow the blood-changes and the visceral disturbances that have been described. In the neighborhood of the bite the tissues are infiltrated with hemorrhages and with the results of rapidly-extending gangrene, the right heart is engorged, the general blood-mass is fluid, and all the internal organs, especially the brain, spinal cord, and kidneys, are congested and present multiple ecchymoses.

Treatment.—When a bite by a venomous serpent has been received, instantaneous and energetic efforts must be made to prevent the entrance of the venom into the general circulation. When the bite has been upon any portion of a limb, a ligature should at once be thrown around the limb above the wound, and by twisting be drawn so tightly as absolutely to check the circulation of blood in the part. This ligature should be a broad one, so as to diminish later pressure-effects; then free excision of the wounded part should be done. When the bite is upon a part of the body other than a limb, immediate excision should be practised, and, when this is impracticable, vigorous suction of the wound should be made, which can be done without fear if no cracks or abrasions of the lips or mouth are present, for the poison is harmless when taken into the mouth. Should a hot iron be accessible, its vigorous and free application within the wound might safely replace excision or suction. When none of these procedures are practicable or have been only imperfectly applied, there remains the device of permitting the poison to be admitted into the general circulation in instalments by slackening the ligature a little at intervals, and then tightening it again, while constitutional treatment is being resorted to for the purpose of antidoting the poison thus slowly admitted into the circulation. Permanganate of potassium, in 1 per cent. aqueous solution, freely injected by means of a hypodermatic syringe into a serpent's bite, without especial regard to the amount used, is asserted by Lacerda of Rio Janeiro to

be an absolute antidote to serpent-venom, and whenever practicable should be given a trial. Hypodermatic injections of ammonia have also proved useful.

The constitutional treatment available in cases of serpent-bite is limited to the use of cardiac stimulants, especially alcohol, which is to be combined when possible with digitalis; both are to be given freely by the mouth and hypodermatically. The state of the pulse is to be taken as the guide to indicate when the proper amount of stimulation has been reached, it being remembered that alcohol does not act as an antidote to the poison, but simply sustains the vascular and nervous systems while the poison is being eliminated through the natural emunctories. The toxic sequelæ in cases that survive are to be treated upon general principles.

SURGICAL DISEASES DUE TO MICROBIC INFECTION.

As the result of bacteriological investigation, the number of surgical affections which have been demonstrated to be due to infection by a specific microbe has become quite considerable. The processes of suppuration and the general septic disturbances of infected wounds have already received full attention as respects their bacteriological relation. To these must be added a series of distinct surgical diseases in the causation of each of which a specific micro-organism has been demonstrated to be the active agent. This list includes the following diseases: *Anthrax*, *Rabies*, *Glanders*, *Actinomycosis*, *Erysipelas*, *Tetanus*, *Gonorrhea*, *Tuberculosis*, and *Leprosy*. Of these the last five are described elsewhere. The first four it seems proper to consider along with "Poisoned Wounds." They are usually derived from animals.

Rabies is generally admitted to belong to this class, and is accordingly included in the present study, although a satisfactory demonstration of its specific micro-organism has not yet been made.

There is much evidence to show that syphilis also should be included in this list, but the complete and indisputable evidences of its microbic origin are still wanting.

ANTHRAX,

Malignant Pustule, *Wool-sorter's Disease*, *Charbon*, or *Milzbrand*.—A disease caused by infection with a peculiar rod-like bacillus, and characterized by an acute inflammatory primary local lesion, with subsequent general infection of the fluids and tissues of the body, with tendency to rapidly fatal ending. The bacillus of anthrax is the largest of the pathogenic organisms, and was the first to be detected, having been identified as early as 1849 by Pollender in the blood of cattle suffering from the disease. The organism is a straight rod, from 5 to 10 micro-millimeters in length and 1 to 1.25 micro-millimeters in breadth; it is devoid of motion, and in the bodies of living animals multiplies exclusively by segmentation. Under certain conditions in dead nutrient media spore-production also occurs. The disease, according to Pasteur, is spread among animals by germinating spores, which, having become attached to plants and grass, are taken in with the food and develop the primary lesion in the mouth or in the walls of the intestines. The tenacity of life of these spores is very great.

Among animals the herbivora are especially susceptible to the disease, less so the omnivora, and least so the carnivora. The disease occurs in all latitudes and in any portion of the world. It is most widely spread in Russia and Siberia, and is particularly common in Hungary and in certain parts of France and Germany. The disease in man is always acquired from affected animals

or from the products of such animals. Any part or tissue of an animal dead from anthrax is capable of communicating the disease. In its dried state the bacillus is able to preserve its virulence for many years, and through any substance to which it may become attached the disease may be communicated; even the feet and probosces of flies which have alighted upon the diseased animal or upon the infected product may carry the disease, and earth-worms carry it from the buried animals to the grass above. Persons who work in industrial establishments where the products of diseased animals may be among the objects of their labor, as hides, horse-hair, and wool, are peculiarly subject to the disease; hence one of the names by which it has been known, Wool-sorter's disease.

Infection may occur equally from inoculation with the bacillus or with spores. When the skin is the site of the primary lesion, some minute scratch, abrasion, or insect-bite may suffice for the inoculation; the unbroken skin affords ample protection from the virus, but the spores when inhaled or swallowed may reach the circulation through a healthy mucous surface.

Symptoms and Course.—The attention of the surgeon is required only in those cases in which the primary lesion is external; cases in which the bacillus enters the organism through the gastro-intestinal canal or the respiratory passages fall under the domain of internal pathology, and for their description the student is referred to text-books on general medicine.

The character of the primary lesion when external infection has taken place depends upon the anatomical structure of the part affected. If it is dense and vascular, a circumscribed carbuncular inflammation develops—**anthrax carbuncle, malignant pustule**; if the infection is in the midst of loose connective tissue with comparatively scanty blood-supply, a diffused inflammatory infiltration manifests itself—**anthrax œdema**. In either case after infection a variable period of incubation intervenes before the manifestation of special symptoms. This period may be from a few hours to three days; in rare instances a longer period, even of ten to fourteen days, has occurred.

Anthrax Carbuncle.—A slight burning and itching at the point of infection, with the rapid development of a papule surmounted by a small vesicle, which, bursting, discloses a central eschar, are the first manifestations of the disease. The inflammatory infiltration at the base and circumference of this primary papule rapidly increases, with development of a ring of secondary vesicles around the margin of the primary eschar, and with gradual extension of the tissue-necrosis. In rare instances the progress of the disease becomes spontaneously limited at this point; a gradual subsidence of the swelling takes place; the slough becomes detached by suppurative inflammation, and the ulcer heals by granulation. More commonly, the œdema and infiltration continue to spread, the eschar extends, phlebitis and lymphangitis develop, and symptoms of general intoxication follow, terminating speedily in death.

Anthrax Œdema manifests itself by the appearance at the point of infection of a livid diffuse œdema which rapidly spreads in all directions; the swelling may become enormous in its extent and size, and at different points local gangrene of the skin and subcutaneous tissue may occur, preceded by the formation of blebs upon the surface, filled with bloody serum. In rare instances spontaneous recovery from this variety of anthrax takes place.

The local pain is slight, and, as long as the diseased process is limited, there is but little general elevation of temperature, the patient often continuing to be about and manifesting simply slight chills and mild fever. General infection is shown by well-marked rigors, high fever, with great weakness, delirium, feeble pulse, sweating, diarrhea, and acute pains in many portions of

the body. Cough, rapid respiration, and cyanosis indicate pulmonary disturbance. Collapse, often sudden in its development, closes the scene.

Pathology.—The tissue-changes which are discernible in cases of anthrax are dependent upon the multiplication and diffusion of the bacilli in the capillaries and lymphatics. The local changes of oedema and necrosis are due to the blocking up of the capillaries by the bacilli and to their irritating effect upon the capillary walls, which produces such abundant inflammatory exudation into the paravascular and connective-tissue spaces that acute ischemia results. When general infection has taken place, the capillaries in every part of the body teem with bacilli, which accumulate in largest numbers at points where the blood-current is slowest. In the most vascular organs, like the spleen, liver, and kidneys, the bacilli especially abound. They form thrombi in the capillaries and lymphatics, from which multiple and more or less extensive extravasations into all the tissues result, and transudations into the various serous cavities are produced.

Diagnosis.—The typical anthrax carbuncle is not likely to be confounded with any other affection. The early superficial depressed eschar, the tough slough closely attached to the surrounding tissues, the lack of sensitiveness of the swelling, the widely-extending infiltration, the absence of suppuration, and the general symptoms which attend its later course form a picture distinct from that which characterizes simple inflammatory carbuncle with its prominent center, its multiple soft, suppurating, sloughing foci, its local pain, and indolent inflammatory course. The multiple small carbuncles of glanders have little in common with the carbuncle of anthrax. Anthrax oedema at its outset may be confounded with acute phlegmonous inflammation or with malignant oedema. Phlegmonous inflammation is characterized by its tendency to suppuration, which at once distinguishes it from anthrax. In malignant oedema the necrosis is attended with rapid disintegration and liquefaction of the dead tissue, in marked contrast with the tough and adherent sloughs of anthrax.

In all cases of suspected anthrax microscopic examination of the fluids of the affected part should be made. The anthrax bacillus can be readily stained and identified under the microscope. Microscopic findings may be made still more positive by inoculation experiments.

Prognosis.—External anthrax which is allowed to take its own course, or in which the treatment is too long delayed, is very grave, but when an early diagnosis is made and energetic, rational treatment is at once instituted, the prognosis is usually favorable. When general infection of the system has occurred, the result is uniformly fatal. The prognosis of the oedematous variety is more grave than that of the carbuncular, in consequence of the greater liability to general infection which attends the former. In either case the fatal termination is due, probably, as indicated by the most recent researches of bacteriologists (Bollinger), to toxic ptomaines formed in the body by the bacilli as the products of their growth.

Treatment.—All treatment must be conducted upon antiseptic lines, and should be energetic, and instituted at the earliest possible moment. Excision of the infected area should, if possible, be done, the incisions being carried wide of the disease, through healthy tissue if possible; special care must be taken to prevent infection of the operative wound from the diseased mass that is excised. To guard against the results of possible infection, the exposed surface remaining after the excision should be thoroughly mopped over with a strong solution of carbolic acid, 1 : 10, or even with the pure acid, or of chloride of zinc, 1 : 8, or the actual cautery may be applied. The immediate application of the actual cautery at the seat of inoculation, whenever such an inocu-

lation is recognized as having taken place, will destroy the virus and prevent subsequent evil. When excision of the entire infected area is impracticable, multiple deep crucial incisions should be made into it, accompanied by injections of carbolic acid, 1:10, by means of a hypodermatic syringe, systematically administered so as to diffuse the carbolic solution throughout the entire extent of the base of the affected tissue and through the surrounding healthy tissue. The punctures should be made just outside the borders of infiltration, the needle passed to the center of the infected area, and the solution slowly expelled as the needle is withdrawn. The carbolic solution should be mopped freely into the cuts, and injections should also be made into the substance of the diseased mass, so as to thoroughly saturate it with the antiseptic, while at the same time an ice-bag should be kept applied upon its surface, and the whole part should be enveloped in compresses saturated with sublimate solution, 1:1000. The carbolic injections may be repeated every six hours until the disease is manifestly under control or until symptoms of carbolic-acid poisoning are developed. The treatment of the subsequent slough is to be conducted on general antiseptic principles.

The constitutional symptoms of prostration and threatening collapse are to be met by stimulant, tonic, and supporting measures.

HYDROPHOBIA (RABIES, LYSSA).

Hydrophobia in man is an infectious disease resulting from the inoculation of a specific virus from an animal suffering from rabies. After a variable period of incubation following the primary inoculation, the disease declares itself by certain spasmodic muscular phenomena, followed by great general prostration and ultimate rapidly-ascending paralysis, significant of lesions of the spinal cord, in which organ, especially the medulla oblongata, the effects of the virus are chiefly centered.

Etiology.—Hydrophobia in man is always the result of inoculations with the virus of a rabid animal, most frequently the dog (90 per cent.), less frequently cats, wolves, and foxes. There is no proof that even among animals there is any spontaneous development of rabies: among them, as in man, it is always caused by direct inoculation from an already rabid animal. There is reason to believe that the bite of an infected dog even during the period of incubation of the disease may produce hydrophobia in man (Bollinger). The lack of disposition to bite upon the part of a dog during this period, however, renders the danger of such an occurrence comparatively small. Instances are recorded where the disease has resulted from accidental wounds sustained during the post-mortem examination of rabid dogs and in laboratory experiments. Not all persons bitten by rabid animals develop hydrophobia. In the nature of the case it is impossible to secure reliable statistics on this point. In many cases, certainly, bites are inflicted by dogs supposed to be rabid, but that are in fact not so; in other cases bites have been inflicted by dogs really rabid in which the infecting saliva was wiped off by the clothing through which the teeth passed, and the wounds were thus preserved from infection. In yet other cases wounds that were really infected have been subjected to adequate immediate cauterization, and thus the later development of the disease prevented. There is, however, sufficient experience to warrant the general statement that about 12 to 14 per cent. of those who are bitten develop the disease (Roux), and of these all die. As regards immunity, no relation is traceable either to age or sex.

While the ordinary medium of infection is the saliva of a rabid animal, the

disease can also be produced by inoculation with other fluids and tissues of such an animal. All the conditions relating to the propagation, development, and course of the disease indicate that it is due to a specific micro-organism, which, by its multiplication within the body, finally causes the ultimate overwhelming symptoms of the disease. This micro-organism, however, has not as yet been satisfactorily demonstrated.

Pathology.—No well-defined, gross pathological changes attend hydrophobia. Microscopic examination of the medulla oblongata and the spinal cord shows irritative lesions, marked by an infiltration of the perivascular sheaths with leucocytes, which at points may be accumulated in considerable number. Hyperemia and moderate œdema of the brain and spinal cord and their membranes as a rule are present. The pharynx, fauces, and neighboring lymphatic glands are usually congested, as is also the mucous membrane of the stomach and intestinal canal; the lungs and kidneys present general diffused, congestive conditions, the whole condition indicating the presence in the circulating fluid of an intense irritant. The heart, spleen and liver are, as a rule, normal.

Symptoms.—*Stage of Incubation.*—A period varying greatly in length intervenes between the time of inoculation and the appearance of any constitutional disturbance. The average period of incubation is about six weeks; it is seldom less than fourteen days, and may be protracted to some months. There is credible evidence that in extremely rare cases this period has been prolonged to between one and two years. During this time the persons bitten feel well and present no symptoms whatever of the dormant disease; the local wound heals kindly. In the young the period of incubation averages less than in the old.

Premonitory Stage.—The outbreak of general symptoms is usually preceded by a brief period, generally not more than twenty-four hours, rarely extended to two or three days, during which ill-defined premonitory symptoms manifest themselves; some uneasiness or pain is felt in the region of the wound, the cicatrix of which may become congested and tender; in other cases all such local symptoms are absent. Symptoms of constitutional disturbance declare themselves with headache, loss of appetite, sleeplessness, and much mental depression and irritability, with tendency to aimless wandering about, accompanied by great anxiety and apprehension, especially if the patient recalls the fact that he has been bitten. A general hyperesthesia soon shows itself, as evinced by sensitiveness to currents of air and to light. The stage of the full development of the disease is now ushered in by noticeable spasms of the muscles of deglutition, causing a sense of tightness and choking about the pharynx, producing difficulty in speaking and in swallowing, and hence dread of fluids, although there is intense thirst. Examination of the pharynx will show that its mucous membrane is congested and that there is an abundant secretion of viscid saliva, which, since it cannot be swallowed, causes frequent hawking and spitting to get rid of it. Occasionally the precursory symptoms are absent, and the first manifestations of the disease are spasmodic contractions of the pharynx occurring while attempting to drink or precipitated by some mental agitation; at other times some oppression of breathing is first noticed, culminating in marked suffocative attacks from spasmodic contractions of the upper respiratory muscles, combined usually with the already described pharyngeal symptoms.

Stage of Excitement.—The disease has now fully declared itself. The spasms of the muscles of deglutition and respiration are more marked and more easily excited; swallowing becomes impossible; the mere suggestion of

it suffices to bring on spasm. Currents of air, an unexpected touch, the slightest source of agitation, will suffice to provoke the convulsion. The embarrassment of the breathing caused by the spasms of the respiratory muscles is often great, producing a sensation of impending suffocation; frequently the entire muscular system will share in the convulsive attacks. These successive muscular spasms are separated by periods of complete relaxation, there being no tonic spasms, as in tetanus.

The mental faculties remain for the most part unimpaired, though excitement, anxiety, and terror occupy the mind. Intervals during which hallucinations develop are common. The duration of the convulsive paroxysms is variable; they rarely continue longer than from one-half to three-quarters of an hour, and usually for a much shorter period. During the paroxysms the excitability and restlessness of the patient, combined with dyspnea and with hallucinations, may produce a condition similar to mania. In the intervals between the attacks the mind appears clear: these intervals are likewise of variable length, very brief at times, at others prolonged for several hours. In rare instances the convulsive paroxysms are completely absent, the patient complaining merely of great anxiety and difficulty in breathing. In exceptional cases the patient is able to swallow food during the entire course of the disease, although the act is accompanied by pain. As a rule, the taking of solid food is impossible, but in exceptional cases such food is swallowed without difficulty. The pulse at the beginning of the attack is normal in character, but, as the disease progresses, grows gradually weaker and quicker, until as death approaches it is no longer perceptible. The body-temperature is somewhat increased, ranging from 100° to 103° F., seldom rising as high as 105° . The urine is scanty, free from albumen, and frequently contains an appreciable amount of sugar.

This stage of excitement may prevail from thirty-six to seventy-two hours; during its course death may occur amid the convulsions from exhaustion or from asphyxia; more frequently there is a gradual transition to a state of comparative tranquillity—the last stage of the disease, the *stage of paralysis*. There is then a gradual remission of the severe symptoms; the reflex nervous excitability diminishes, resulting in freer respiration and the recovery of the ability to swallow, while the general debility and prostration rapidly increase. The convulsions become feebler and cease entirely. If life is sufficiently prolonged, a condition of rapidly-ascending paralysis supervenes, and symptoms of respiratory and cardiac failure develop, terminating in death. The duration of the final stage of hydrophobia is brief, being, as a rule, between two and eighteen hours.

Diagnosis.—Hydrophobia is to be distinguished from tetanus, from the effects of mental agitation and fear simulating hydrophobia (hydrophobia imaginaria, lyssophobia), and from certain forms of hysteria and epilepsy in which symptoms affecting the organs of deglutition are manifested analogous to those observed in genuine rabies. The positive history of a bite from a probably rabid animal, the prolonged period of incubation in hydrophobia, the fact that in this disease the spasms affect the muscles of deglutition, and not those of mastication, as in tetanus, and are not tonic in their character, and that the respiratory embarrassment is due to spasm of the laryngeal muscles, and not to those of the chest, will suffice to distinguish between these affections if any doubt should otherwise exist. The pseudo-hydrophobic symptoms which are sometimes manifested in the course of other affections of the nervous system are distinguished, as a rule, by the absence of the general reflex excitability which is a marked feature of genuine hydrophobia. The development of symptoms closely

simulating genuine hydrophobia, through the effects of fear and anxiety, in persons of highly excitable and imaginative temperament who have been bitten by animals which were not rabid, is well authenticated. Such cases may even proceed to a fatal termination, although, as a rule, under appropriate treatment recovery takes place; which fact is sufficient to demonstrate that the case was not one of true hydrophobia. Upon the result of an examination of all the circumstances that surround the case must depend the conclusion as to the real character of such an attack.

Prognosis.—The prognosis is absolutely hopeless in genuine hydrophobia when once the symptoms of the disease have declared themselves.

Treatment.—*Palliative treatment* is all that any case admits of, but the utmost importance attaches to prophylaxis. The patient should be kept in a dark and quiet room, and as absolutely free from every source of agitation as possible. Morphia should be administered hypodermatically in amounts sufficient to relieve pain. The severity of the spasmodic paroxysms should be mitigated by inhalations of chloroform. Thirst should be relieved as far as possible by rectal enemata.

Prophylaxis.—Every wound inflicted by a possibly rabid animal should be subjected as soon as possible either to free excision or to thorough cauterization. In any interval that must elapse until this can be done constriction should be applied upon the proximal side of the wound if possible. If the part bitten is one in which the knife can be used freely, excision is preferable, the cuts being made wide of the bitten part, the resultant wound being thoroughly disinfected and sutured or treated openly as its special conditions may require. If cauterization is more feasible, it should be done with the actual cautery if possible, which should be applied deeply and thoroughly. Of chemical caustics, caustic potash or fuming nitric acid is to be preferred.

Prophylactic inoculations with emulsions of the dried spinal cords of rabbits infected with hydrophobia, after the method of Pasteur, have certainly been proved to be of value in establishing absolute immunity against the strongest hydrophobic infection if the series of inoculations is completed a sufficient time before the actual development of constitutional symptoms. The earlier the inoculations are begun after the infection has been received, the greater the certainty of the immunity conferred by them. The practical application of the method depends upon the discovery that the virulence of such infected spinal cords may be reduced progressively from the highest degree to nothing, according to the length of time during which the cord is preserved in a dry and pure atmosphere, fourteen days' drying being sufficient to destroy all virulence. Injections are made, beginning with emulsions of the weakest virulence and passing gradually to the strongest. The duration of treatment varies slightly according to the severity of the bites. In bites about the head the incubation period is often very short; in such cases, therefore, promptness of action is especially necessary, and in order to save time the number of injections made during the earlier days of the treatment is increased.

Institutions for carrying on this method of treatment have been established in various parts of the world. The result of these inoculations, made at the institute of Pasteur during the five years 1886–1890, is, that of 7925 persons who had been bitten by animals either proven by experiment to have been suffering from rabies or recognized by veterinary surgeons as suffering from that disease, and who had then submitted to the inoculations, only 73 had died, a mortality of but 0.92 per cent. In view, therefore, of these results, and in view of the great danger of the possible development of hydrophobic symptoms in a person bitten by an animal suffering from rabies, and the utter hope-

lessness attending the progress of such an attack, it would be the part of wisdom in all cases of bites from presumably rabid animals to subject such patients to the Pasteur treatment if possible.

GLANDERS (FARCY; EQUINIA).

Glanders is a contagious, eruptive, ulcerative disease, primarily of horses and their congeners, asses and mules, caused by their infection with a specific micro-organism, the *bacillus mallei* (p. 9). It is capable of being transmitted to men, as well as to many of the lower animals, by inoculation. The special manifestations and course of the disease vary much, being dependent upon the location and character of the tissues first inoculated and the amount and virulence of the inoculating material.

The bacillus of glanders is a small rod, somewhat shorter and broader than the tubercle bacillus; it is either straight or slightly curved, rounded at its ends, and is usually found in pairs, the two lying parallel with each other and held together by a delicate pellicle. The existence of spores is in doubt. The bacilli may be killed by exposure for ten minutes to a temperature of 131° F. (55° C.). Carbolic acid in 5 per cent. solution destroys them in five minutes, and corrosive sublimate in 1 : 5000 solution in two minutes. Their tenacity of life under ordinary circumstances is great, so that virus that has been in the dried condition for many months may be effective.

Etiology.—Infection occurs usually through some abrasion or wound; the possibility, however, of infection through an unbroken skin by rubbing the virus into the hair-follicles has been demonstrated. Inoculation through an unbroken surface along the mucous lining of the nasal and respiratory passages, or the conjunctiva, is not rare through the lodgment thereon of particles of infected muco-pus deposited there by the snortings of infected animals. As a rule, diseased horses are the source of infection in the human subject; in rare instances the disease has been transmitted from man to man. But a small proportion of the persons who are exposed to infection develop the disease.

Pathological Anatomy.—The histological changes determined by the presence of the bacillus in the tissues consist of a low grade of inflammation, resulting in the formation of nodules of embryonal or granulation-tissue, which speedily break down into pus, forming more or less extensive abscesses, which, when they open upon free surfaces, degenerate into ill-conditioned phagedenic ulcers with undermined edges, surrounded by extensive areas of inflammation. Dissemination of this series of diseased processes may take place throughout all the organs and regions of the body by continuous extension, by transmission along lymphatic channels, and by emboli carried in the blood-stream. The lesions of glanders appear first in the skin and the subcutaneous cellular tissue, and upon the mucous membrane of the nares and respiratory passages. Post-mortem examinations show similar lesions in the lungs, many of the muscles, the larger joints, and the great viscera. The cartilages and bones are likewise involved, sometimes primarily, but more frequently secondarily through contiguity. The lesions of ordinary pyemia are super-added to the specific lesions of glanders as soon as the suppurative processes become at all general.

Symptoms.—The symptoms that follow infection with glanders may be rapid in their course, manifesting a high grade of malignancy, and terminating in death within two or three weeks, or they may be slower in their development and progress, extending over a period of many months; hence the classification which has been made into *Acute* and *Chronic Glanders*. When the

lesions are well marked and abundant in the skin, the special term **Farcy** has been applied, more particularly to the disease among horses.

After infection a stage of incubation of varying length elapses, usually of but a few days, but possibly prolonged to two or three weeks. Vague symptoms of general malaise usher in the special symptoms of the disease; an inflammatory nodule appears at the point of inoculation, attended with pain and an extending zone of inflammatory congestion, involving especially the lymphatic trunks; fever develops; the primary nodule suppurates and breaks down into an ill-conditioned phagedenic ulcer. If the primary lesion is in the mucous membrane of the nose, the progressive ulceration soon destroys the soft parts and attacks the bones, the neighboring tissues of the face, pharynx, and palate become involved, and the whole of the face and neck becomes swollen and inflamed. In the further course of the disease, without regard to the seat of the primary lesion, multiple nodules develop on different parts of the skin; these quickly suppurate and degenerate into offensive ulcers, or larger swellings and abscesses are formed which become converted into extensive and deeply-burrowing ulcers. These diffused skin lesions may appear within one or two days from the onset of the attack, or their appearance may be delayed some weeks. In the second or third week of the attack an outbreak occurs upon the mucous surfaces, primarily that of the nose if it has not been the seat of the original lesion. Other mucous surfaces—of the eye, mouth, fauces, respiratory and gastro-intestinal tracts—rapidly take on the same conditions. If the infection has been an internal one, the gastro-intestinal disturbance, the fever, and the general prostration may cause the case to simulate for a time typhoid fever. The due development of external manifestations suffices in time to correct the error. In cases running an acute course febrile exacerbations become marked. The emaciation and prostration increase, all the symptoms of profound septic infection develop, with delirium, terminating in stupor and final death in collapse. In some cases the fatal result is accelerated by the disturbances consequent upon bronchial and pulmonary conditions.

In those cases which pursue a *chronic course* the development of the lesions is more gradual and less generalized. The constitutional symptoms depend upon the number, size, and situation of the local lesions, and upon the amount of general septic infection which is present. Often, cases after pursuing a chronic course for a time take on an acute character and rapidly hasten to a fatal termination; in other cases death occurs from exhaustion and septicemia or from pulmonary and bronchial complications. Many chronic cases, however, ultimately display a gradual amelioration of all the symptoms; cicatrization of the ulcers and healing of the abscesses slowly take place, and eventual recovery is secured, more or less perfect, but the patient is always seriously crippled. The average duration of the chronic form is about four months.

Diagnosis.—The acute form in its earlier stages is liable to be confounded with acute suppurative lesions, and even, in some of its manifestations, with rheumatism and typhoid fever. Its later manifestations may be referred to pyemia, which usually complicates it, but when the local phenomena are once fully developed the diagnosis is free from uncertainty; the knowledge that a patient has had to do with horses will aid in forming a diagnosis. The chronic form is more likely to be confounded with syphilis or tuberculosis. Where doubt exists search should be made for the specific micro-organisms in the nodules or the discharges; their detection will render the diagnosis positive. Inoculation experiments on animals may also be resorted to.

Prognosis.—The acute form of glanders is always fatal. When it man-

ifests a tendency to run a chronic course the prognosis is relatively favorable, for about one-half such cases ultimately recover. As long as the lesions remain limited to regions accessible to direct surgical treatment hope may be entertained of securing a cure.

Treatment.—Prophylaxis is of the utmost importance. This consists simply in the immediate destruction of all animals affected or suspected; the burning of all substances soiled with the infecting discharges; and the utmost carefulness on the part of all persons having to do with infected animals to guard against the possibility of inoculation.

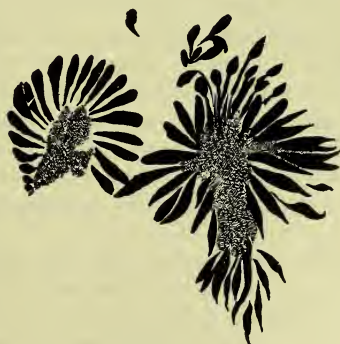
When a point of inoculation has occurred, immediate thorough disinfection and cauterization should be done. If nodules and abscesses develop, they should be at once thoroughly laid open, curetted, and disinfected. Chloride of zinc in solution, 1 : 8, is to be recommended for such disinfection. All surfaces that have been affected should be subjected to continuous antiseptic applications. The general treatment must consist of tonics, nutrients, and stimulants freely administered.

ACTINOMYCOSIS.

Actinomyces is an infectious disease due to the presence in the tissues of a peculiar fungus, termed actinomyces (ray fungus), and characterized by the development of tumor-like masses at the points of infection, which readily undergo softening and suppuration, with continuous extension of the original process into adjacent tissue (Fig. 21).

Etiology.—The source from which the infecting fungus is derived has not been determined. The disease has as yet been found only among herbivorous and omnivorous animals, including man. The medium of infection is probably some article of food. The recognition of the disease as a specific one is of recent origin. Bollinger first, in 1877, described the relation of the fungus to certain swellings of the lower jaw in cattle. Its recognition in man is due to the labors of Israel and Ponfick, especially the latter, the results of whose researches were published in 1882. Since attention was called to it many cases, not a few of which have occurred in the United States, have been identified by different observers. The disease has heretofore been confounded with sarcoma, since the granulation-tissue which composes the greater mass of the tumors has the microscopical structure of the round-cell sarcoma. Section through the tumor, however, will show many soft, sulphur-yellow colored spots in strong contrast with the general reddish tissue of the growth. If the tumor has already fallen into suppuration, the pus will be found to contain numbers of sulphur-yellow miliary bodies; these are frequently united together in clusters, and have a soft consistence and an unctuous feel. By pressure these clusters are easily separated into smaller granules. These little granules, when viewed under the microscope, are found to consist of intertwined mycelia, the single threads of which have bulbous termini. In many cases a single filament will terminate in a mass of bulbs

FIG. 21.



Actinomyces.

branching in various directions. A frequent, and apparently the highest, type of development is when the granule is composed of a multitude of filaments radiating from a common center, their bulbous termini presenting upon the periphery. That this ray fungus is the specific cause of the disease has been established by cultivation and inoculation experiments.

Pathological Anatomy.—The primary effect of the lodgment of the fungus in the tissues is to excite a low grade of chronic inflammation, resulting in the accumulation of a mass of granulation-tissue, in the midst of which the fungus is imbedded. By the continued formation and accumulation of such masses swellings of considerable size result. The disease may remain stationary in this stage for an indefinite time, though, as a rule, degenerative processes begin early, the breaking down of the tumor resulting from a process of suppurative inflammation. The fungus is probably not itself pyogenic; the supuration that occurs is due to secondary infection with pus-microbes.

Symptoms.—In cattle the disease occurs most frequently in the lower jaw, hence the name “lumpy jaw” by which it has been characterized; in man, likewise, the lower jaw is most frequently affected, and in a very large proportion of cases the disease has its site in some tissue adjacent to the mouth (of 73 cases reported by Moosbrugger, in 41 the jaws, mouth, throat, tongue, or œsophagus were involved; in 14, the respiratory tract; in 11, the intestines; in the remaining 7 the point of infection was not ascertained). Wherever the disease is, the symptoms are those of an ill-defined, slowly-increasing swelling. The lymphatics are not involved, and there are no glandular enlargements until secondary infection has occurred; suppuration sets in early when the growth is in regions most likely to be infected with pus-microbes. A chronic abscess is now inaugurated, and the local and constitutional symptoms which follow are due to the activity of the secondary infective process and the extent of the septic infection which results. Diffusion of the actinomycetes, with the development of the disease in distant organs and parts of the body, may occur when the fungus or its spores have obtained entrance into the general circulation through an opening in a vein-wall which may have occurred during the process of ulceration: such general dissemination is of rare occurrence. In general, the disease remains localized, and extends steadily from the original point of infection into adjacent tissues, invading every tissue with which it comes in contact, irrespective of its anatomical structure. Before suppuration takes place the swelling is quite firm on pressure and free from pain and tenderness; the condition of suppurative inflammation, once established, favors the growth and extension of the specific disease by setting free and diffusing the actinomycetes. The pus discharging from actinomycotic abscesses always contains the actinomycetes, which can usually be detected by the naked eye as minute yellowish granules.

Diagnosis.—The presence of the specific fungus in the granulation-tissue or mingled with the pus is the one diagnostic feature of actinomycosis. It has been most frequently confounded with sarcoma; in some of its manifestations it may be mistaken for syphiloma or tuberculosis; sarcoma does not suppurate and break down as early as the actinomycotic granuloma. Tuberculosis is attended with glandular infection, actinomycosis, previous to secondary infection, not at all; in suspected syphiloma adequate specific treatment will suffice to establish its presence or absence within a few weeks. In any case, resort to the microscope should be made as early as possible, and the detection of the fungus will positively establish the diagnosis.

Prognosis.—The clinical course of actinomycosis is that of a malignant tumor. Without radical surgical treatment it tends to indefinite extension, and

ultimate death by exhaustion, sepsis, or pyemia. When the disease is early recognized and the affected part is susceptible of thorough extirpation, a cure may be obtained.

Treatment.—Absolute extirpation of all infected tissue should be done whenever practicable, the incisions being carried through sound tissue at some distance from the visibly infected part. If this is impracticable, the suppurating cavities and sinuses should be laid open freely and the surrounding infected tissue should be excised as far as possible; thorough curetting of the remaining diseased tissue should be done, followed by numerous injections of a strong carbolic solution (1:20) into the substance of the tumor that may still remain. Into any sinuses that have not been fully laid open tampons saturated with solution of chloride of zinc (1:8) should be packed, and the whole diseased surface that has been exposed should be dressed with similar tampons. The wound should be kept open and the curetting and cauterization repeated as often as any suspicious points show themselves. Recently-published experiences of veterinarians indicate that iodide of potassium given internally in full doses, pushed to the point of iodism, has a specific curative effect upon actinomycosis in a large proportion of cases in cattle. It should therefore be given a trial in cases in human beings.

CHAPTER XVII.

SYPHILIS.

SYPHILIS¹ is an infectious, contagious, and inoculable disease, transmissible also by heredity. It first manifests itself by an indurated or infecting chancre, followed by general lymphatic enlargement, afterward by eruptions of the skin, usually symmetrical and at first superficial, and by allied conditions of the mucous membranes, later by chronic inflammation and infiltration of the cellulo-vascular tissue and bones and periosteum, and finally by special productions in the form of small swellings, which may invade any tissue or organ of the body, but chiefly involve the connective tissue, and are known as gummata.

During all the acute symptoms, and for a period extending over several years, the patient has acquired an immunity against fresh infection. The disease is probably caused by the entrance of a specific microbe into the system, and although the final and conclusive evidence, consisting of the isolation, culture, propagation, and re-inoculation of the micro-organism, is still lacking, the clinical facts alone are sufficient, in the light of our present knowledge of the microbic diseases, to place syphilis in that class. Considered in this manner, as has been done by Finger, the various symptoms and stages of syphilis are to be explained as follows:

The general symptoms in the primary stage of syphilis—the languor, fever, malaise, pain, etc.—are due to intoxication by the ptomaines produced by the virus, as these symptoms are too ephemeral and changing to be ascribed to localizations of the virus. In the secondary stage the various eruptions on the skin and mucous membranes are caused by local deposits of the virus. Their virulence proves this; but a great many of the so-called secondary symptoms

¹The histology and pathology of syphilis will doubtless before long have to be rewritten from the bacteriological standpoint. At present the observations of Cornil are the most accurate and reliable in our possession, and have been closely followed in this work. (See Cornil *On Syphilis*, American edition.)

are of intoxicative character, being due to tissue-products passing into the circulation, and causing a general, often severe, nutritive derangement. After the second stage comes a long stage of latency—for many a period of cure; for others, only an interval between the second and third stages. That the virus still exists in the body is shown in many cases by its hereditary transmission. The general health is not perfect. The immunity against fresh infection is the chief characteristic of the above latent period. We do not know how long it lasts, but its duration is certainly limited, in some cases at least, as the undoubted cases of re-infection show. The immunity, as mentioned, began even in the primary period. It is an immunity only against fresh virus. The first virus which caused the infection may still cause relapses.

The immunity in the primary stage is due to tissue-products of the virus in the circulation, the infected foci being still strictly localized. In support of this there is the undeniable fact that, under certain conditions, persons may acquire immunity against syphilis without passing through its stages. Hereditary syphilis teaches us this. The specific products of syphilis have been taken into account in explaining the following two kinds of immunity from syphilis: 1. Colles's immunity; 2. Profeta's immunity. By Colles's immunity is meant that which is shown by those healthy mothers who, owing to syphilis in the father, have borne syphilitic children, but have themselves apparently escaped infection. This immunity has been proved in thousands of cases, and there is no longer any doubt that it may exist. Caspary and Neumann even inoculated without result, and Finger has done so three times. The immunity in such cases is due to the tissue-products of the syphilitic virus which have passed from the fetus, by diffusion, into the maternal circulation, causing immunity from syphilis without the symptoms of syphilis. It is true exceptions are published, but they are few and uncertain. Profeta's immunity ("*la loi de Profeta*," Fournier) is the immunity of the children of syphilitic parents, either or both being syphilitic. The children in many such cases are born healthy and remain healthy, but some of them are proof against the contagion of syphilis just as if they had had the disease. This immunity also is due to tissue-products of the virus passing into the foetal blood, and not to the entrance of the virus itself.

In fact, all immunity from syphilis (and the same holds with all other infectious diseases) is due to the "tissue-products" of its organized virus passing into the circulation; for (1) this immunity occurs even in the primary period; (2) it outlasts the period of activity, and even that of the presence of the virus in the body; (3) it can be transferred independently of the virus itself. How this immunity is to be explained essentially is, however, still an open question. Tertiary symptoms are not due to the syphilitic virus *per se*, but to its tissue-products. A moderate amount of tissue-products of the virus (or only slight virulence or greater resistance of the body) causes simple immunity; an increased amount or greater virulence of morbid products of the virus causes tertiary syphilis. It has frequently been asserted that there is no relation between the various stages of syphilis, as there is none between the character of the syphilis of the person who supplies the poison and that of the one who receives the infection. Certain cases, however, will be grave or "malignant" from the earliest period, and the dosage of virus or a feeble power of resistance in normal cells may well be factors in determining this gravity. The definition given above includes all the periods of the disease, which are as follows:

First. Period of primary incubation, or that intervening between the exposure to contagion and the appearance of the chancre, on an average about three weeks.

Second. **Period of primary symptoms** (chancre and adenitis).

Third. **Period of secondary incubation**, or that between the appearance of the chancre and the development of secondary symptoms, on an average about six weeks.

Fourth. **Period of secondary symptoms** (syphilides of the skin and mucous membranes, mucous patches, roseola, papules, pustules, etc.). This period may last from one to three years.

Fifth. **Intermediate period**, during which there may be no symptoms, or irregular, slight, and less-symmetrical and less-generalized manifestations. The patient is protected as regards fresh contagion, but if he begets children they are likely to suffer. This period is very variable, lasting from two to four years and ending in complete recovery or in

Sixth. **Period of tertiary symptoms** (tuberculo-ulcerous syphilides, periostitis, osteitis, gummata, etc.). The duration of this period is unlimited.

This separation of syphilis into periods is, to a certain extent, artificial, but it corresponds, however, to the course of most cases, and is desirable for purposes of dogmatic description.

In considering the **methods of transmission** of syphilis, it must never be forgotten that it is not necessarily a venereal disease. While it most frequently has its origin in sexual connection, yet it quite often occurs from the contact of the buccal mucous membrane of a nursing child with the nipple of its nurse, or *vice versa*, or by the common use of the same drinking-glasses, etc., or midwives and physicians may be infected in practising the vaginal touch. It is the secretion from a chancre or mucous patch which most frequently determines the disease: the result is always an infecting chancre. The theory of the transmission of syphilis from *all* the lesions of venereal disease—*i. e.* the doctrine of the identity of gonorrhea and chancres—prevailed without opposition during several centuries. At the present time it is entirely abandoned.

When a person is exposed to impure connection, the lesions do not immediately intervene; there occurs a period of from two to four weeks, an average of twenty-one to twenty-five days, before any symptoms appear, and sometimes a longer time elapses—six weeks or two months.

This period of incubation, which precedes the appearance of the indurated chancre, is known as the **period of primary incubation**. Whenever an inoculation, whether intentional (as in some unjustifiable experiments which have been made) or accidental, with the secretion or pus of a secondary lesion or with the blood, is successful, it produces a chancre, preceded by this long period of incubation, and the symptoms of syphilis are then developed in their regular evolution and successively appear. Mucous patches and moist papules not only have the power of causing a chancre and syphilis by contact, but are probably the most frequent source of its transmission. Syphilis transmitted by a syphilitic nursing infant suffering with mucous patches of the lips is seen as a chancre upon the nipple of the nurse, provided the latter is not its mother and has never had syphilis. Again, syphilitic papules of the nipples of a syphilitic nurse occasion a chancre upon the lip of a healthy infant.

Secondary lesions of syphilis may extend over a long time. Syphilis may thus be communicated by a syphilitic person for several years after the beginning of the disease. In marrying during this period there is danger of communicating the disease to the wife and of having syphilitic children.

There has been, as far as we know, not one trustworthy case of the transmission of syphilis by means of any of the normal secretions, even where the most careful and persistent attempts at inoculation have been made. Thus there are no reliable cases of syphilitic contagion by the spermatic fluid or of inoc-

ulation by this liquid. The tears and saliva obtained from syphilitic persons have been inoculated upon healthy persons without producing the disease.

As the blood itself is undoubtedly contagious and inoculable, while the fluids of the various secretions do not possess these properties, it is very probable that the passage of the serum of the blood through the glandular membranes and cells arrests the contagious particles and renders the secreted fluids harmless. Whatever may be the lesion or fluid or organism determining the transmission of syphilis, it appears that except in cases of hereditary syphilis the result is always the same, an infecting chancre, preceded by a period of incubation.

SECTION I.—PRIMARY SYPHILIS.

The Chancre.—We are not in possession of absolutely conclusive evidence as to whether or not the virus of syphilis remains localized during the period of primary incubation, but it is probable that when inserted under the skin it remains there a certain length of time without any other action than gradually to prepare the cells which are in immediate relation with it for the hyperplasia which soon constitutes the chancre.

The chancre always appears at the point of inoculation. If we suppose that the syphilitic poison is from the first carried everywhere in the economy, it is difficult to understand why there is not, during one or two months, any other lesion elsewhere than at the point of entrance. The primary lesion is invariably met with at the point inoculated, never elsewhere; and secondarily, a neighboring gland is swollen after the appearance of the chancre, then several glands; such glands, as we know from our study of other diseases, arrest for some time the diffusion or generalization of morbid products and tumors.

This conception of the localization of the virus at the beginning of the contamination is very important in a practical point of view. It would indicate that the destruction of the chancre at the moment of its appearance would prevent syphilis. While there is great difference of opinion among syphilographers upon this point, the weight of authority is against the probability of the abortion of syphilis by excising or otherwise destroying the chancre. Most authorities are agreed, however, that cauterization or excision of an abraded or absorbing surface soon after exposure, and *before* the development of the chancre, is strongly indicated, and has probably in several cases prevented constitutional infection.

The infecting chancre has a period of incubation varying from ten days to six weeks, the average being about three weeks.

It is an excellent general rule for prognosis in cases of suspicious ulcers upon the genitals to assume that if an interval of ten days or more has elapsed between the last exposure to contagion and the development of the sore, the latter is probably the initial lesion of syphilis.

It begins sometimes by a superficial papule, which generally extends in circumference and depth; sometimes by an excoriation or a superficial fissure, often very slight. As it spreads upon the skin there are seen accompanying redness and desquamation of the epidermis; upon the mucous membranes a superficial abrasion or an ulceration covered by a grayish or yellowish false membrane; there is also observed an induration, sometimes giving the sensation of a hard nodule, fibrous or cartilaginous; at other times, that of a thin plate like parchment or paper. There may be no absolute loss of epidermis over the surface of a chancre, but merely a gradual thinning of the epidermic layers from the margins of the sore toward its center. Ulceration, when it exists, is a simple cup-shaped depression; its surface is smooth and the margins are not

abrupt. At the center of the chancre there is found a false membrane, beneath which is a raw vascular layer, bleeding readily.

Section of a chancre shows, in addition to the usual lesions of cutaneous inflammation, a special and characteristic change—a sclerosis or thickening of the coats of the venules and arterioles, affecting chiefly the tunica adventitia. This thickening of the arterioles and venules is very important. In connection with the preservation of the firm trabeculæ of the derm and of most of the fasciculi of the connective tissue and of the elastic tissue, it gives to the infecting chancre its most essential clinical character—the induration.

The induration may be either superficial or deep, depending upon the arrangement of the vessels, which form on the skin two horizontal networks—one beneath the papillæ, the other deeper at the base of the derm. When the former is affected we have a superficial induration. If the sclerosis has involved at the same time both sets of vessels, the intermediate branches being equally affected, we have a more extensive nodule, varying in thickness according to the region of the skin involved.

In the first case the induration is foliaceous or parchment-like; in the second it is woody and gives the sensation of cartilage. Almost always the sclerosis is continued along the coats of the vessels farther than the induration itself. These lesions do not develop very rapidly; which fact, taken in connection with the changes of the tissues involved, explains the long duration of a chancre and the persistence of the indurated nodule.

The induration of a chancre usually occurs at the end of the first week, dating from its appearance; it may not show itself until much later. The induration is progressively developed from the surface—that is, from the papillary network—to the deep cutaneous and subcutaneous layers.

The variations in thickness of the affected part give rise to different degrees of induration. *Laminated* induration is thinner and less distinct than the parchment variety, and gives to the fingers the sensation of a piece of paper. *Parchment* induration is that which gives to the fingers applied to the circumference of the chancre the sensation of a piece of parchment forming the base of the erosion. *Nodular* induration is that in which the base of the chancre is hard and thick, feeling between the fingers like a nodule of cartilage or wood; it is the most characteristic. *Annular* induration is that in which only the margins of the chancre are indurated and form a hard ring, the tissue in the center retaining its normal elasticity.

The most readily recognized and the most characteristic chancre has the shape of a cup-like depression seated upon the indurated and elevated skin.

The histological relations of the connective tissue and vessels beneath the chancre will explain the anatomical reasons for these several forms of induration. The laminated or parchment induration corresponds to a sclerosis limited to the papillæ of the derm and to the vascular network of the papillæ; deeper or nodular induration corresponds to a sclerosis of the cutaneous and subcutaneous connective tissue and of the vascular network of these parts, which latter is much larger than the superficial network, and is therefore slower in forming and in disappearing than a similar lesion of small vessels.

Traces of induration have been observed four or five years after the beginning of the chancre. Ricord has found remains of the induration ten and fifteen years subsequent to the primary lesion.

The induration and its extent are best appreciated by seizing the chancre at its margin between the thumb and finger, drawing it upward, so that it may move upon the subcutaneous tissue, and then using slight pressure in a direction parallel to the surface of the chancre.

The degree of induration varies very much according to the seat or region of the primary lesion. When occurring upon the glans penis, upon the mucous membrane of the prepuce, or in the fossa glandis, the chancre is generally very distinctly indurated; upon the skin of the penis and the general integuments the induration is not so marked or extensive. In women the induration of the chancre is greater upon the labia majora than upon the labia minora and fourchette.

The induration of an infecting chancre is not only variable, but, in rare cases, it may be absent. Therefore it is not positive and constant, and Cornil believes that induration is a symptom less important in infecting chancre than the characters of the erosion and the condition of the surface of the chancre, especially if, in addition to these, we take cognizance of the several indurated, movable, painless, and hypertrophied lymphatic glands, which never suppurate unless the chancre has been irritated by caustic or other applications followed by infection with pyogenic microbes.

The induration generally does not remain at its height longer than three or four weeks, and the chancre heals entirely in five or six weeks; but the indurated nodule, if it were primarily large and cartilaginous, may persist and be still recognizable for years.

According to Fournier, three times in four the indurated chancre is single. Multiple infecting chancres all begin at the same time, for the primary lesion of syphilis is not, as a rule, auto-inoculable, and therefore it has no tendency to be reproduced alongside of the primary sore, as is the case with chancroid.

The **appearance** of infecting chancre is varied. Between an erosion or slight abrasion situated upon a parchment-like base that may be readily overlooked, and an ulceration with a nodular cartilaginous base of considerable size, even an inch in diameter, there are found several intermediate degrees.

The **most frequent seat** of chancres is the genital region; they are very seldom met with upon other parts of the body; this is especially true with men, less so in the case of women.

The usual seat of chancres of the genital organs with men is the glans penis, the internal surface of the prepuce, and especially the fossa glandis and frenum. Three-fourths of all chancres are found in these localities. At times they are found upon the skin of the penis, at the meatus urinarius, upon the scrotum, in the urethra, or upon the groin.

In women the labia majora are the most common seat of genital chancres; then follow the fourchette, the labia minora, the clitoris, the skin of the pubes or groin, the neck of the uterus, etc.

It is doubtful if an infecting chancre has in a single instance been found upon the vagina, and yet this canal is certainly the part most exposed to contagion. This immunity may possibly be due to the structure of the vaginal mucous membrane, which is covered with thick layers of pavement epithelial cells, and to the absence of glandular orifices over its entire surface; the vaginal mucous membrane possessing papillæ and prominent villi, but no glands.

Extra-genital chancres, particularly those of the anus, are very much more common in women than in men, yet all chancres of the anus in women do not indicate unnatural sexual relations: the anal orifice is so situated that in dorsal decubitis the fluids from the vulva flow over and often contaminate it.

Anal chancres are usually situated at the margin of the anus, at the bottom of one of the radiating folds of skin produced by the contraction of the external sphincter. The ulceration is apt to follow the lines of these folds, and thus to assume an elongated or linear character. They are hard, and do not give rise to the painful symptoms of fissures of the anus. They have been observed as high as the upper margin of the internal sphincter.

The seats of extra-genital chancres are the anus, mouth, lips, tongue, uvula, palatine arches, tonsils, cheek, nipple, etc. A cephalic chancre is almost always infecting. Chancroid is scarcely ever seen upon the lips or face.

The **diagnosis of chancre** is a matter of such great practical importance that it may be well, even at the risk of repetition, to enter into it somewhat fully:¹

1. In dealing with lesions *apparently non-venereal* in their origin and character we should consider carefully the following points:

(a) The *anatomical situation* and the *course* of the lesion. Among those particularly to be viewed with suspicion may be mentioned herpetiform erosions of the lips, papules on the tip of the tongue, squamous or "scabby" ulcerations of the skin, scratches which obstinately refuse to heal, chronic inflammations at the tip of the fingers resembling felons, etc.

(b) *Indolence, absence of suppurative tendencies, and persistence in spite of treatment* are negative signs which should lead us to believe that any cutaneous or mucous lesion is not of a simple nature.

(c) *If the morbid products are slight*, rather serous than purulent, tend to form into crusts or to assume a pseudo-membranous form upon an eroded surface, syphilis should be suspected.

(d) The *consistence of the base* upon which the lesion is situated is one of the most important diagnostic points, and should always be carefully investigated. If, upon palpation, instead of the usual inflammatory swelling and thickening, shading off into the surrounding tissue, we meet with a cartilaginous, elastic, sharply-circumscribed resistance, we may immediately suspect very strongly that we are dealing with a syphilitic lesion, although even this symptom cannot be considered as infallible.

(e) If the *lymphatics of the groin* become slightly swollen and painful and progress no farther, or if these symptoms occurring in a single gland subside spontaneously, it is probable that they are due to a sympathetic adenitis, such as follows many irritations of the skin or mucous membrane. If, on the contrary, they steadily augment in size and hardness, are almost painless, and constitute a chain of little tumors including several or all the inguinal glands, it may be considered strong presumptive evidence of specific disease, though even yet not conclusive.

In addition to these points the history of the case must carefully be inquired into—the probabilities of infection, in regard to which we should not be misled by the beliefs of the patient—and the period of incubation, which, when it can be clearly established, is of great value.

Confrontation—i. e. examination of the person from whom the disease has probably been contracted—will often, not invariably, decide the matter, but, in this country at least, is rarely obtainable.

Difficulties of diagnosis are greatest during the first week or ten days, and steadily diminish with the age of the lesion, which, if syphilitic, is almost certain to assume in time a definite character. The chief points among those mentioned are the period of incubation, the presence or absence of induration, and the condition of the nearest lymphatic glands. If, however, all of these seem to point to syphilis, the experienced observer will still refrain from giving a positive opinion, no symptom or group of symptoms being absolutely conclusive as to the specific character of any primary lesion; certainty only being attained by the development of some of those general or constitutional phenomena which in from six to eight weeks follow the infecting chancre.

¹ In doing so we shall follow closely the paper of Ch. Mauriac, which is the best résumé of this subject with which we are acquainted.

2. The *region occupied* by a chancre may cause errors or difficulties in diagnosis.

(a) In the *cephalic region* chancres of the *hairy scalp*, of the supraorbital prominences, and of the chin and cheeks are the most deceptive. They always assume an ecthymatous form, and are so concealed by the hair that it is impossible to judge of the character of their surface. In all such cases the hair must be carefully shaved, and if we then find that we are dealing with an ulceration lacking the ordinary characteristics of ecthyma, and glazed, flat, or even elevated, our suspicions should be aroused, and after eight or ten days will usually be confirmed, if the sore is syphilitic, by the development of induration and of neighboring lymphatic enlargement.

Razor-cuts on the chin, cheeks, or lips which, after having healed, reopen and become covered with a crust, should on *a priori* grounds be suspected. This is equally true of pseudo-furuncles, acneiform pustules, cracks around the circumference of the nostrils, etc., which persist without giving rise to pain, and become bloody, encrusted, and surrounded by an area of subinflammatory, œdematous swelling. We should then carefully examine the preauricular, parotidean, and submaxillary lymphatic glands.

A *style* which behaves in an unaccustomed manner or is accompanied by hyperplasia of the lid, or a conjunctivitis which becomes localized and causes an isolated swelling, should be attentively watched.

In the *neighborhood of the mouth* errors of diagnosis should be less frequent than in other portions of the cephalic region, because it has been shown so often that the lips, tongue, and fauces are frequently brought into contact with syphilitic discharges and constitute one of the principal channels of infection. Here, however, as elsewhere, the chancre assumes at the very outset the appearance of ordinary lesions. Thus, upon the lips the chap, crack, or fissure often found in the median line, the little aphthous erosions, herpetic ulcerations, and cigar or cigarette burns, simulate very closely the characters of the initial lesion, and, as the latter will almost invariably be attributed by patients to some such ordinary cause, may give rise to serious error.

At the end of the first week, however, the specific characters of labial chancre are usually so distinct as to render diagnosis easy.

In several instances these chancres have been mistaken for epithelioma, and have been excised. The diagnostic differences may be indicated as follows:

Labial Chancre.

No marked difference between the sexes.

The ulcer may involve either lip.

Occurs at any age.

Patient often strong and robust.

Is insensitve.

Regular in outline, smooth surface, elevated.

Indurated and sharply circumscribed base.

Evolution of sore usually occupies a few weeks at the most.

Glandular involvement follows closely on appearance of sore.

No marked odor from secretion of sore.

History of exposure to syphilitic inoculation often obtainable.

Heals rapidly or disappears under mercurial treatment.

Epithelioma.

Twenty times more common in males than in females.

Almost invariably situated upon the lower lip.

Rarely occurs before middle life.

Patient usually in impaired health.

Often sharp, burning, lancinating pains.

Irregular in outline, ragged, filled with fungous granulations, bleeding easily.

Induration less cartilaginous, unequal, not clearly circumscribed, and more extensive. Sore may be months in developing after its first appearance.

Glands are not implicated for three or four months, often not until later.

Odor often extremely offensive.

Frequently no such history.

Not affected or rendered worse by such treatment.

While there is a possibility of error in diagnosis between a chancre and an epitheliomatous ulcer when a macroscopical examination alone is made, there is, on the contrary, no such apprehension when a microscopical examination of the lesions is instituted. The histological structure and arrangement are so very distinct and unlike in these lesions that a mistake cannot well occur. In the epithelioma we have the ingrowing of the interpapillary layers of epithelial cells, the branching or budding outgrowths from the sebaceous glands which constitute the very characteristic epitheliomatous pegs, and the formation of the cell-nests or pearls upon these pegs, which are all so strikingly different, when contrasted with the histological structure of a chancre, that no doubt as to diagnosis remains.

Upon the *sides of the tongue* ulcerations, produced by the continual contact of that organ with rough and carious teeth, have been mistaken for chancres. This error should be guarded against, but is not so serious in its results as the failure to recognize the specific lesion when it is situated at the point of the tongue, the possibility of its communication to innocent people being, in such cases, an element of unusual importance.¹ In the first five or six days it is impossible to diagnosticate it, but if the original little inflamed papule enlarges and extends, becoming elevated above the surrounding parts; if its epithelial covering drops off and its surface becomes diphtheritic; if superficial cauterization with crayons of nitrate of silver, which so rapidly cure the common small painful papule of the tongue, have no effect upon it,—there is a strong presumption that it is chancre. This will be confirmed later by the appearance of submaxillary glandular enlargement and induration of the sore.

Of all the chancres of the cephalic region, however, that of the *tonsils* or of the *isthmus of the fauces* presents the greatest diagnostic difficulties, on account of the effacement of its characteristics by the surrounding inflammation. If in a case of prolonged sore throat there be an appearance resembling a single mucous patch, and there be no history of antecedent syphilitic poisoning, it becomes probable that the trouble is chancreous; and this probability is greatly increased if any induration can be felt by palpation with one finger in the pharynx and another external to its walls; if enlargement of the glands above the angle of the jaw occurs; or, of course, if the patient confesses to having been peculiarly exposed to contamination.

The sore is much more common in this region in females than in males, Mackenzie noting the fact that out of 7 cases of primary syphilis of the tonsils which he had met with, 6 were women.

(b) *Superior and Inferior Extremities*.—Chancres of the *hands* are often seated at the margin of the nail and closely resemble simple whitlows. They may be diagnosed by their long duration, their abrupt limitation, the hardness of the tissues around and beneath them, and the consecutive engorgement of the epitrochlear ganglion. Upon the dorsal face of the phalanges the initial lesion at first simulates an inflamed papule or boil, but is less painful, discharges no “core,” and is elevated, not excavated.

The anterior face of the *forearm* in both sexes, the anterior surface of the *thigh* in men and the posterior surface in women, are the parts most exposed to contagion.

The chancre of *vaccino-syphilis* occurs after the evolution of the vaccine sore. It can only be confounded with the ulcerations described by Blot under the name of “vaccinal phagedenism,” which are rounded with abrupt borders and indurated bases, and are often accompanied with engorgement of the axil-

¹ The same remark applies to mucous patches of the tongue and lips with even more force, as they are so much more frequent than primary sores.

lary lymphatic glands. The diagnosis from appearances is difficult, but may be made by noticing the fact that these sores run an acute course, and are readily cured by poultices or emollient applications, which, of course, have no effect on chancre.

(c) Upon the *trunk* the *mammary* and *hypogastric* regions are those most frequently involved. In the former locality the initial lesion is most likely to be mistaken for eczematous excoriations, fissures, and small furuncular or papillary tumors. The diagnosis rests upon the presence of the characteristic induration, elevation, etc., and upon the polyganglionic axillary enlargement. In cases where syphilis has been transmitted during suckling confrontation is almost invariably possible and furnishes the most satisfactory guide.

Chancres of the hypogastrium are generally large and ulcerating, and are most liable to be mistaken for chancroids.

(d) *Genital Organs.*—The diagnosis of sores situated in this locality is chiefly between chancre, chancroid, and herpetic ulceration. The diagnostic table given below expresses the main points of difference.

Chancre.	Chancroid.	Herpetic Ulceration.
<i>Origin:</i> Due to contagion from a chancre, a syphilitic lesion, or blood or pus from a person having syphilis.	Usually due to contact with pus from a similar sore, or to accidental inoculation of the secretion of a chancroid upon a person already affected with syphilis; often to the irritation of pus from other sources.	Mechanical irritation; friction, as in sexual intercourse; chemical irritation, as of acrid discharges; uncleanliness. Occasionally follows cold or fever; may be a neurosis.
<i>Incubation:</i> Not less than ten days; often three weeks; very rarely six to eight weeks.	None.	None.
<i>Situation:</i> Most frequent upon the genitals. Often seen on the hands, nipples, lips, etc.	Almost always upon the glans penis or prepuce; rare upon other portions of the genitals; scarcely ever seen elsewhere.	Glans penis and inner layer of prepuce.
<i>Commencement:</i> Begins as an erosion, papule, tubercle, or ulcer. May remain without ulceration through its entire course.	Begins as a pustule or ulcer.	Begins as a group of vesicles, which may coalesce or may ulcerate singly.
<i>Number:</i> Single or simultaneously multiple; occasionally, but rarely, successively multiple.	Often multiple, frequently by auto-inoculation.	Multiple; apt to be confluent.
<i>Shape:</i> Round, oval, or symmetrically irregular.	Round, oval, or unsymmetrically irregular, with border described by segments of large circles.	Irregular; edges serrated or described by segments of small circles.
<i>Depth:</i> Usually superficial — cup-shaped or saucer-shaped — or may be elevated.	Hollow, excavated, or "punched out."	Superficial.
<i>Surface:</i> Smooth, shining, red, glazed; diphtheritic membrane or scab.	Rough, uneven, "worm-eaten," warty, whitish-grayish, pultaceous.	Same as local ulcer, but more superficial.

Secretion :

Scanty, serous, auto-inoculable with great difficulty, producing either a chancreoid sore or, in rare cases, a second sore like the first.

Abundant, purulent; readily auto-inoculated

Moderate secretion; auto-inoculated with difficulty.

Induration :

Almost always present; firm, cartilaginous, or parchment-like; circumscribed, terminating abruptly; movable upon subjacent parts; skin not adherent; usually persistent: disappears under specific treatment.

Only exceptionally present; may be caused by caustics or other irritants, or by simple inflammation; boggy, inelastic, shades off into surrounding parts, to which it is adherent; disappears soon after cicatrization.

Same as local ulcer.

Sensibility :

Very little or no pain.

Painful.

Painful.

Course :

Usually regularly progressive toward health, the sore often healing spontaneously. Phagedena uncommon. Second attack also very rare.

Irregular; may cicatrize rapidly or may extend, taking on phagedenic action. No protection against a second attack.

May spread, in exceptional cases, by the appearance of successive crops of vesicles. Usually heals promptly under mild local treatment. Likely to recur, especially in uncleanly patients with long fore-skins.

Histology :

A new cell-growth. Very little destruction of tissue.

An ulceration, with more or less loss of substance.

Originally an elevation of the epidermis in spots by an effusion of serum.

Bubo :

Constant, painless, multiple.

In one-third of the cases; painful, inflammatory, single.

Rare. When it does occur, painful, single, inflammatory.

Prognosis :

Good locally; constitutional syphilis will follow in the great majority of cases, but in a few may not appear or may be prevented by treatment.

More serious, locally, on account of loss of tissue; occasional refusal to heal, and possibility of phagedena. *Very* rarely is followed by syphilis.

Always good if the diagnosis be absolute. Should be guarded when there is the least doubt as to the herpetic character of the affection.

Treatment :

Excision when seen early; other local treatment of minor importance.

Local treatment curative.

Local treatment curative.

Chancres of the meatus are more often syphilitic than simple in their character. In the former case they are attended with little or no ulceration, are confined to one lip of the meatus, are accompanied by the usual induration and glandular involvement, and are often, indeed usually, not discovered by the patient, who imagines he has a gonorrhea. Chancroid of the meatus is irregular in shape, ulcerated, involves both lips, is painful, and does not have the characteristic induration.

The diagnosis between infecting urethral chancre and gonorrhea may be tabulated as follows :

Urethral Chancre.

Symptoms appear after a period of incubation rarely less than ten days, often two or three weeks.

Confined to meatus or its immediate neighborhood.

Ardor urinæ felt only at lips; no chordee.

Discharge moderate, never purulent, often bloody.

Induration perceptible to touch, usually involving only one lip of meatus.

Invariable enlargement of chain of inguinal lymphatics, which are painless and freely movable, and almost never suppurate.

Sore can almost always be seen as a loss of continuity of mucous membrane.

Constitutional symptoms follow after from six to eight weeks.

Use of syringe painful at meatus.

Urethritis.

Symptoms follow suspicious intercourse in from twenty-four hours to a week, rarely at a longer interval.

Begins at meatus, but extends some distance backward.

Ardor urinæ felt along the urethra; chordee often present.

Discharge more profuse, decidedly purulent, not so often or so largely stained with blood.

No induration.

If lymphatics are involved at all, only one is affected, which often goes on to supuration.

No loss of continuity perceptible.

No constitutional symptoms.

Use of syringe not usually painful.

The small hard tumors which occasionally appear or may be felt along the under surface of the penis during an attack of gonorrhea, and which are due to inflammation and enlargement of the follicles, should not be confused with chancre. They usually feel like grains of sand or small peas directly beneath the skin, are situated behind the fossa navicularis, have no characteristic induration, and subside spontaneously or go on to suppuration.

When phimosis exists the diagnosis between subpreputial chancres and chancroidal, herpetic, or balanitic ulcerations is often one of great difficulty. It should be founded on the following considerations:

Subpreputial Chancre.

The incubation is that of chancres, ten to twenty-one days or more.

If the site of the original trouble can be felt or can be described by the patient, it will be found to be single.

Inflammatory phenomena comparatively slight.

Swelling hard, dry, indurated characteristically.

The discharge from the preputial orifice is moderate, thin, serous or bloody, not readily inoculable.

The margins of the preputial orifice are not markedly inflamed or ulcerated.

At some point the induration can probably be isolated from the surrounding tissues and raised and felt between the thumb and finger.

Syphilitic buboes are invariably present.

Subpreputial Ulceration (non-syphilitic).

The interval between the exposure and the subsequent ulceration, swelling, etc. is much shorter.

Several points of ulceration, abrasion, or pustulation will usually be found or described.

Inflammatory phenomena—heat, pain, redness, swelling—very marked.

Swelling oedematous, sero-purulent, like that of phlegmonous erysipelas.

Discharge profuse, purulent, usually very irritating, and apt to be inoculable, both accidentally and experimentally.

Almost invariably ulcerated.

This is usually not possible, no distinct dividing line existing.

Buboes, if present at all, are of an inflammatory character.

The diagnosis between a new indurated chancre and an ulceration occupying the site of an old chancre, the induration of which has never entirely disappeared—"relapsing chancre"—is extremely difficult, and, unless a clear history of the case can be obtained, is impossible. The latter cases are often reported as instances of a second syphilitic infection. The opinion must be

based upon the presence or absence of a syphilitic history and the circumstances of the exposure, incubation, etc. The possible effect of local irritation on an old indurated mass should always be taken into account.

The prognosis of syphilitic chancre, considered as a local affection, depends chiefly upon the seat of the lesion. A chancre of the conjunctiva may give rise to a grave ophthalmia; a chancre of the tongue or of the fauces may cause great debility through interference with mastication, deglutition, and digestion. As regards the genital organs, however, the prognosis is almost uniformly favorable. Phagedenic or gangrenous processes are rare; ulceration even is usually very slight, or, if seemingly extensive, is apt to be at the expense of the neoplasm, and not of the normal tissues.

The relation between the constitutional disease of which the chancre is the precursor and the sore itself is a question of great interest. It may be at once acknowledged, however, that our information upon this point is deficient. We are able neither to predict the form of local lesion from the character of the source of infection, nor, on the other hand, can we, with any accuracy, forecast the constitutional condition which will result from any given sore. The varieties of the chancre in form, extent, etc. depend more upon local causes or upon the idiosyncrasies of the patient than upon any special source or peculiarity of the virus. Every syphilographer of experience has seen the most widely-differing forms of initial lesion derived from the same individual, and a similar diversity exists in the forms of constitutional disease arising from a given focus of infection. The amount of glandular implication is also an entirely unreliable guide and presents all sorts of variable phenomena.

The Treatment of Chancre.—Every surgeon whose work has brought him in contact with large numbers of cases of venereal sores must recognize the fact that between the typical soft, suppurating local sore and the distinctly indurated chancre there are large numbers of doubtful ulcers which partake of the characteristics of both: local sores with deceptive inflammatory hardening, and true chancres with equally deceptive inflammatory softening, suppuration, and even loss of substance. Nearly every specialist who has written upon the subject has recognized and been influenced by this well-known fact.

Fournier, perhaps the most eminent living syphilographer, has recorded a case which bears most strongly upon the question under consideration: A female child, six years old, was said to have been infected with syphilis during an attempt at rape. She had marked vulvitis, and upon the labia three grayish, shallow, indolent, indurated ulcers covered with a diphtheritic-looking membrane and raised a little above the general surface. In both groins there were enlarged, multiple lymphatic glands. He positively diagnosed chancre, but, conforming to his custom in medico-legal cases, declined to testify for a few days. During this time, under a simple dressing, the symptoms disappeared, and the patient, who was carefully observed for several months, never showed any subsequent signs of infection. Fournier believes that the case demonstrates that small inflammatory lesions may so closely resemble chancres as to deceive the most experienced surgeon, and adds that in medico-legal cases the diagnosis should not be made upon the local lesions alone, but should depend upon the development of constitutional symptoms.

The surgeon who is daily called upon to give an opinion in cases which involve the whole future of the individual, his relations to the other sex, his determination toward celibacy or matrimony, his matrimonial relations if he should be already married, the question of the influence of paternity, the institution of a course of treatment extending over years, the diagnosis of any obscure visceral troubles which he may develop later in life, the profoundly

depressing mental effect which a knowledge of syphilitic infection usually has upon intelligent people,—the surgeon who remembers these facts and recalls the views above cited as to the possibility of error should surely hesitate about beginning a course of treatment which will possibly obscure or render altogether impossible the diagnosis. While there is no positive advantage in delay as regards the subsequent course of the case, yet, on the other hand, the gain from the immediate treatment during the primary sore is not sufficient to counterbalance the doubt and uncertainty which that treatment often throws about the future life of the patient. Certainly the cases are comparatively rare in which a careful surgeon would be willing to make an *absolute* diagnosis of syphilis during the existence of the primary sore alone. A few necessary exceptions to this rule may be included under the following heads:

1. Where confrontation is possible and the sore is distinctly a typical one.
2. Where with a typical sore its continued existence would destroy or imperil the conjugal relations of two people or possibly the happiness of an entire family.
3. Sores with characteristic induration, but with marked tendency to spread and involve important regions.
4. Sores in such conspicuous positions, as upon the lips or the nose, that their continuance would involve a general knowledge of the patient's condition.

With these exceptions it is the part of wisdom to wait until the development of glandular enlargement at some point removed from the initial lesion, and not, therefore, by any possibility a result of simple adenitis, demonstrates the constitutional character of the trouble. It is to be hoped—and, indeed, may be confidently expected—that the progress of bacterial investigation will in the near future enable us to make a very early and positive diagnosis, but we cannot do so as yet. It is not necessary, however, to wait for the syphilodermata. Treatment may be safely begun when, after a suspicious sore upon the genitals, consecutive enlargement of the epitrochlear or post-cervical lymphatic glands takes place.

The argument above used against the mercurial treatment of chancre applies with equal force to the local abortive measures which have from time to time been recommended. These include *excision*; *cauterization*; *antiseptic measures*; and various *local applications* of mercurial preparations by means of ointments, hypodermatic injections, or otherwise. Taking them in the order mentioned, their relative advantages and disadvantages seem to be as follows:

As to *excision*, it appears unquestionable that it can be of service in but a very small proportion of venereal sores as they usually come under the notice of the practitioner. The opinions of syphilographers, however, vary greatly in regard to the value of this form of treatment, and in the light of the opposing views a safe general rule for practice is to assume that a sore seen within a few days after its appearance, and as yet unaccompanied by any enlargement of the inguinal glands, is still a localized lesion. If favorably situated—*i. e.* upon the skin of the prepuce or of the genitals—it may be removed, the surgeon picking up the sore and surrounding tissue with a pair of toothed forceps, and removing it by a single sweep of the knife or by means of scissors curved on the flat, afterward dressing the wound with iodoform or boracic powder. By this plan of treatment we give our patients whatever small chance there may be of avoiding constitutional disease, while at the same time we expose them to the minimum degree of local pain and disturbance.

When the patient refuses this treatment, or when the sore is so situated that its removal would cause considerable pain, hemorrhage, or deformity, destructive *cauterization* with fuming nitric acid may be employed. In all cases (and these comprise the majority which come for treatment) in which

a week or more has elapsed since the development of the sore, and in which involvement of the dorsal lymphatics of the penis and the inguinal lymphatic glands is observable, cauterization as a routine method of treatment should be rejected, on account of its undoubted uselessness at that stage in preventing constitutional disease; the pain which it causes; the inflammatory action which follows it, and which often produces enough œdema and swelling to cause phimosis, and thus convert an open sore into a hidden one; the subsequent effusion of lymph, which simulates true induration and confuses the diagnosis; and, finally, the greater liability to the production of suppurative action in the ordinarily indolent bubo of syphilis.

The so-called *antiseptic treatment* of the initial lesion of syphilis is a misnomer, so far as the essential character of the sore is concerned, unless it be meant to include only the thorough destructive cauterization of all portions of the infected tissue. Applied simply to superficial dressings placed over the chancre, it can refer only to the prevention of the development of pyogenic organisms upon the surface of the sore. As the tendency of infecting chancres to suppurate is generally unimportant, we can hardly expect advantages from the employment of aseptic or antiseptic methods which are at all commensurate with those obtained by the same methods in ordinary surgical conditions.

The *local treatment* by hypodermatic injection of mercurials beneath the base of the initial lesion and into the mass of indurated lymphatic glands rests upon the view that mercury acts as an antidote when brought directly into contact with the syphilitic germs, and that this influence would probably be especially active if the drug were brought to bear directly upon the local lesions which are the foci of infection during primary syphilis. If we believe that the virus remains localized for a time after inoculation, and is not disseminated through the general system, and that mercury acts by its germicidal influence, this treatment is not unphilosophical, but seems inferior to the more thorough plan of excising both the chancre and the enlarged lymphatics of the groin. The latter procedure would be less likely to result in local troubles, such as abscess or cellulitis, and would certainly be more effective. The rules as to the treatment of chancre may accordingly be expressed as follows:

1. While it is unquestionably desirable to begin mercurial treatment at the earliest proper moment, and while that treatment undoubtedly either suppresses or renders milder the subsequent secondary manifestations, and while there is every reason to believe that in this way the liability to later or tertiary lesions is somewhat lessened, nevertheless the sum-total of these advantages does not warrant the employment of mercury one moment before the diagnosis of constitutional disease is absolutely assured.

2. While in many cases that diagnosis can be made with a high degree of probability from the appearance of the primary sore alone, yet it cannot be said that all possibility of error is excluded until some general symptom, such as the enlargement of distant lymphatic glands, has shown itself.

3. The administration of mercury during the existence of the primary sore, unaccompanied by general symptoms, for the purpose of suppressing or "aborting" syphilis, is not, therefore, justifiable, unless by confrontation the diagnosis can be confirmed, or unless there are urgent and unquestionable reasons for securing rapid cicatrization of the chancre.

4. It is proper to employ cauterization or excision, according to the site of the chancre, in cases in which it is seen very soon after its appearance, and especially when it is known to have followed intercourse with a syphilitic person. The chances of preventing constitutional infection in this way, while slight, may yet be considered sufficient in such cases to counterbalance the dis-

advantages of the method, such as pain, swelling, the production of phimosi or of suppurating bubo, and the obscuring of the diagnosis by the resulting inflammatory exudation.

5. Aseptic or antiseptic measures, while harmless, cannot be considered especially indicated in the local treatment of chancre, and in all probability can have no true abortive influence.

6. The local use of mercurials, hypodermatically or by inunction, is perhaps worth a trial, but it is probably inferior to the more radical methods based essentially upon the same principles—namely, excision and cauterization.

Chancroid.—The form of sore known as soft sore, soft chancre, simple chancre, non-infecting chancre, and chancroid is variously ascribed to the inoculation of a specific virus (the chancroidal), to infection with pus-microbes, and to a mixed (syphilitic and purulent) infection. There is some reason to think that there is a specific virus for chancroid. No final conclusion can yet be stated, though bacteriology will doubtless definitely settle the matter at no distant period. In the mean time we may be content to consider chancroid as a sore which has a very different appearance and runs a very different course from an infecting chancre.

In the case of a chancroid there are observed from the first certain phenomena. The first day we see a small red point, which on the second day becomes a papule, and is converted into a pustule by the end of the second or third day, especially in a region where the skin is delicate. The pustule soon breaks, and beneath the lowest epidermic layers we find a deep suppurating ulcer, which rapidly extends in circumference and depth, becoming at the end of the first week deep and crater-like with perpendicular or undermined edges; its surface is granulating, irregular, and infiltrated with pus, which is abundant and gives it a grayish color. The serum upon the surface of an indurated chancre, on the contrary, is small in amount and transparent.

In the chancroid there is no sclerosis of the vascular walls; we meet with the phenomena of inflammation, but there is no induration or thickening of the wall and no narrowing of the caliber of the vessels. The fibrous trabeculae of the derm of the region involved are not preserved intact. The fibrils separated by the lymph-cells are themselves destroyed by the softening of the tissue and by the suppuration. These changes upon the surface of a chancroid result in the fibrous tissue losing its firmness and elasticity; its fibrous trabeculae have a tendency to disappear. The lymph-cells, which collect in great numbers in the granulations and neighboring connective tissue, are large, turgid, and become free by softening the fibrils between which they are placed. The absence of specific induration comparable to that of the indurated chancre, and also a tendency to a progressive destructive involvement of neighboring tissues, result from this anatomical arrangement of elements. From this it will be seen that between chancre and chancroid there is a marked histological difference, one being essentially a prominent papule or new growth, the other an ulcer. A chancroid is apt to be painful and itching; the pus, which is secreted in large amount, is inoculable upon the patient, who frequently inoculates himself inadvertently or from uncleanness, so that it is often multiple.

Phagedena.—Either a chancroid or a chancre, but oftener the former, may be accompanied by such intense local infection and tissue-necrosis that it spreads with great rapidity both on the surface and toward the deeper structures. It may thus produce one of the most destructive and most obstinate forms of ulceration. It is not known certainly whether this indicates essentially a lessened power of resistance or a new microbic infection. Probably both conditions coexist in the majority of cases.

When the lymphatic glands are affected there may occur a true suppurating bubo, especially if the patient be broken down in health or if he has been negligent of treatment. In this case an inguinal gland is swollen, fixed, and becomes very large; the skin reddens upon its surface, and we soon feel a superficial fluctuation, due to pus formed in the cellulose-adipose tissue surrounding the gland. When this abscess is opened the gland in some cases suppurates, and there is formed an irregular cavity which secretes sanious pus; the skin constituting its borders is red, inflamed, and separated from the tissue beneath. These glandular abscesses, like the chancroid, sometimes become phagedenic.

Chancroid is variable in its duration, which is sometimes quite short, lasting three, four, or five weeks; at other times it continues several months, and sometimes, if it is phagedenic, one or more years.

The Treatment of Chancroid.—While it has been for many years the custom to cauterize freely all soft or suppurating venereal ulcers—*i. e.* all sores diagnosticated as chancroid, whether situated in the genital regions or elsewhere—the introduction into surgery of the principles of antiseptis, and with them of such drugs as iodoform, has greatly modified this routine treatment. It is safe to say that chancroids are neither so frequent nor so severe as they were years ago, and that by the application of antiseptic methods to their treatment a great advance has been made in the ease and certainty with which they can be cured.

In a large majority of cases daily irrigation with sublimate solution of 1 : 500 or 1 : 1000, followed by free dusting with iodoform or by the application of an ointment consisting of one and one-half drams of iodoform to one ounce of carbolated cosmoline, will be followed by speedy cicatrization. If these fail, the continuous application by means of pledgets of cotton or lint of a lotion containing sublimate, boric acid, and peroxide of hydrogen will often cure. If, in spite of this, the sore deepens and extends, destructive cauterization with fuming nitric acid or the acid nitrate of mercury is at once the safest and speediest method of cure.

The objections to the cauterization of chancroids are as follows, and are similar to those mentioned in relation to chancres: First. The pain to which it gives rise. Second. The inflammatory action which follows, and which often in the case of the male produces enough œdema and swelling to cause phimosis, and thus to conceal the sore and prevent the proper application of remedies. Third. The subsequent effusion of lymph, which is apt to cause an induration closely resembling that of the true chancre, and thus greatly to obscure the diagnosis.

The general rule may be followed of meeting indications—that is, of using sedative lotions, lead-water, or lead-water and laudanum, or sulphate of zinc and opium—in the acutely inflamed, painful sores; and of using stimulating washes—sulphate of copper, strong zinc solutions, nitrate of silver, etc.—upon indolent, pale, and flabby ulcers. Special indications having been met, iodoform will generally complete the cure.

SYPHILITIC BUBOES.

Almost at the same time that the chancre becomes indurated the lymphatic glands, connected with it by means of the lymphatic vessels, undergo hypertrophy. The glands nearest to an infecting chancre become enlarged and hard; they roll readily beneath the skin; they are painless and do not suppurate. These clinical characters are unvarying. They are found in the groin when the chancre is upon the external genitals; in the submaxillary glands when the chancre is upon the lips; in the axilla when the chancre is upon the nipple or hand.

The glands of the groin, in connection with a chancre upon the genital organs, are successively involved, the gland first affected being the most inferior of the group upon the diseased side. When the chancre is situated at one side of the frenum, it is not uncommon to find the buboes in both groins, a certain amount of decussation occurring between the lymphatics of the former region. The inguinal glands are all hypertrophied, but are distinct one from another, the skin remaining healthy.

About a month and a half after this enlargement of the glands nearest to the chancre all the lymphatic glands of the body are successively invaded, at least all those which are visible. They appear a little inflamed before or at the same time with the eruption of the cutaneous syphilides. Probably all the glands of the economy are affected, and cases of enlargement of the glands in front of the sacral, lumbar, and dorsal vertebræ have been reported. The subcutaneous glands affected by syphilis are the cervical, maxillary, occipital, etc. Among the most important glands for diagnostic purposes are the post-cervical, which do not enlarge from local causes so frequently as the anterior chains of cervical lymphatics (*glandulæ concatenatæ*), and which are therefore almost pathognomonic when they undergo painless multiple enlargement at about the period for the appearance of the early secondaries.

In syphilitic lymphatic glands the follicles of the delicate reticulated tissue are hypertrophied, and occasion small lobulated projections upon their surface when the capsule is removed. These glands remain more or less enlarged, not only during the active period of the secondary lesions, but frequently after the syphilides have disappeared.

The following tables will serve to contrast the buboes and lymphangitis characteristic of the two chief forms of venereal sores:

Syphilitic Bubo.

Always accompanies or follows infecting chancre.

Several glands involved, making a group or chain of small, movable glands in one groin or often in both.

Appears soon after chancre.

Slight enlargement.

Cartilaginous induration.

No inflammatory symptoms.

Glands freely movable.

Skin normal, not adherent.

Painless.

Indolent, slow.

Terminates by resolution, rarely by suppuration.

No marked tendency to phagedæna.

No local treatment effective.

Mercurial treatment hastens resolution.

Inflammatory Bubo.

Occurs in only one-third of the cases of chancreoid; occasionally, but more rarely, in herpetic or balanitic ulceration or in gonorrhea; may follow an infected wound of the lower extremity.

One gland implicated, rarely bilateral.

No definite time of appearance.

Great enlargement.

Inflammatory hardness.

Always present.

Gland fixed (*periadenitis*).

Skin red, adherent.

Painful.

Runs an acute course.

Usually suppurates, rarely undergoes resolution.

Phagedæna not very uncommon.

Local treatment required.

Mercury has no influence upon the condition.

Syphilitic Lymphangitis.

Lymphatic vessels feel hard, like the vas deferens; size of a knitting-needle.

Painless to touch.

No pain on erection.

Skin normal.

Terminates by resolution.

Local treatment unnecessary and ineffective.

Inflammatory Lymphangitis.

Same, but less hardness.

Painful.

Erection gives rise to pain.

Skin red over inflamed vessel.

Resolution or suppuration.

Local treatment of great use.

SECTION II. : GENERAL SYPHILIS.

At about the time of the general lymphatic enlargement—and coincident with or preceding the earliest eruption—we have a characteristic group of symptoms—viz. : 1. *Fever*, varying from 100° F. to 101° F., coming on toward evening and associated with moderate anorexia and malaise. 2. *Muscular and articular pains*, chiefly affecting the muscles and joints of the chest, back, and upper extremities, but sometimes very general and quite severe. 3. *Alopecia*, not confined to the scalp, but involving the hairs of the whole body, distinguished from ordinary baldness by that fact, by the concomitant symptoms of syphilis, and by the irregular, moth-eaten character of the bald spots.

Constitutional syphilis may be diagnosticated when an indurated genital chancre is followed by a painless, hard swelling of the inguinal glands and of others like the post-cervical, which are remote from the spot of local irritation. The change of the lymphatic gland is so characteristic that from it alone the diagnosis of syphilis is possible when the cervical, maxillary, supratrochlear, and other lymphatic glands are invaded, as well as those in the inguinal region, and still more easily when the fever, pains, and alopecia are present.

SECONDARY SYPHILIS.

The eruptions of the skin and mucous membranes soon make their appearance, and constitute the first manifestations of the secondary stage of syphilis.

These **syphilides** usually appear about six weeks after the beginning of the infecting chancre, sometimes sooner; at other times later, even two or two and a half months from the date of the chancre. They are seldom as late as three or four months, yet in rare cases they have occurred after five months have elapsed. The mercurial treatment, when given during the existence of the chancre, has been accused of causing this retardation of syphilides, and doubtless does so, but it must not be forgotten that the evolution of the disease is very variable.

Cutaneous and mucous syphilides are more superficial when they are more recent, and grow deeper as they grow older. Thus the syphilides of the first period of secondary lesions affect only the papillary surface and epidermic layers. These are erythematata, or superficial spots, as roseola; or limited, slight, and temporary inflammations of the papillary and epidermic layers, as papules. The older syphilides, on the contrary, belonging to the later secondary period, appear as pustules or tubercles,¹ which affect the deep cutaneous and subcutaneous layers in connection with the papillary network and epidermis; they are destructive and are followed by cicatrices.

A classification of syphilides similar to that adopted by Cornil and based on their pathological histology is both useful and practical. It is as follows:

1st. **Erythematous syphilides**—erythema; macules; roseola.

2d. **Papular syphilides**—conical, lichen-like syphilide; large papules.—Patches of papulo-lenticular syphilide; papulo-squamous.

3d. **Pustular syphilides**—acneiform; impetiginous; ecthymatous; rupial.

4th. **Gummatous and tubercular syphilides.**

In this classification there is indicated the gradual passage of the superficial lesions of the early period of secondary symptoms into the deeper and later

¹ The word "tubercle" is often used to designate one of the eruptions of syphilis. It refers simply to its visible characteristics, and does not mean that there is any infection with the bacilli of tuberculosis.

lesions of the second period, and finally into the rupia, tubercles, and gum-mata of the third period.

Syphilides of the first period are almost always *polymorphous*; that is, the eruptions present at the same time the different varieties of roseola, papules, and small pustules or squamous papules. In ordinary eczema or impetigo we have the same elementary lesion of the skin at all points, and the same appearance of all the regions affected; but, on the contrary, there are found in syphilis varied elementary lesions, spots of erythema alongside of papules and vesico-pustules, and other lesions modified according to their location. In other cases there will be seen a papular syphilide in a somewhat chronic state; the papules when upon the skin of the limbs appear dry, their epidermis desquamating. In those regions where the skin is in folds, as upon a dependent mammary gland, the papule, instead of being dry, is moist; upon the palm of the hand, where the epidermis is corneous and thick, the epidermic layers over the papule form hard scales, which have incorrectly been compared with psoriasis. This polymorphous condition and the blending together of the elementary lesions are among the best diagnostic characteristics of syphilides. Syphilides of the late secondary period frequently involve all the layers of the derm and epiderm, and are given compound names, as papulo-vesicular, papulopustular, tuberculo-pustular, etc.—names which define themselves.

The syphilides have a *color* which is said to resemble that of copper or of ham; this is owing particularly to extravasations of red blood-corpuscles, and is marked in the eruptions of the first period. The copper color is not seen in lesions of the mucous membranes. Another distinctive characteristic of syphilides, except diffused erythematous roseola, is that they all have a regularly *round shape*, whether isolated or in groups. They form small circles, figures-of-8, etc. Finally, the lymphatic glands are often affected in the region invaded by the eruptions, and the action of mercury upon these eruptions is to cause their rapid disappearance.

The earliest cutaneous symptom in syphilis is almost equally apt to be an **erythema** or a **roseola**, the former a diffused mottling of the surface, affecting chiefly the trunk and abdomen and without appreciable elevation; the latter, somewhat darker in color and apt to show a tendency to become papular. Roseola may indeed be considered as an eruption intermediate between the erythematous and papular syphilides. The diagnosis is usually easy, and can readily be made from simple roseola, the roseola caused by copaiba, by exposure to the atmosphere, by measles, by bites of insects, etc., if the patient be examined with care, if enlarged lymphatic glands and mucous patches are looked for, and, finally, if the special color of the papules and the history of the case be remembered.

The **papular syphilides** may be small or large, and may be associated with such an accumulation of epidermic scales as to receive the name of the papulo-squamous syphilides. The *first* variety (small papules) has received the name of lichen-like or miliary syphilide. The color of the papule is very characteristic. The elevation of the skin is due to a thickening of the papillæ and epidermic layers; but at the summit of the papule and over all the surface forming it the most superficial layers of the corneous epidermis have desquamated, while those at the margin of the papule are continuous with the normal skin of the periphery. The papules remain a varying length of time; they usually disappear in three or four weeks when mercurial treatment has been employed; at other times they continue for two and three months. They are modified according to their location. The mucous patches corresponding to this variety may be small and acuminate. Upon the scalp the eruption appears

as small pustules or papules covered with a yellowish or brown scab; upon the palmar surface of the hands the papules are covered with hard epidermic scales or they are depressed and surrounded by a corneous epidermis.

The *second* variety of papular syphilides is characterized by large papules, having a diameter of from half an inch to an inch, or even larger. In its beginning a pimple is noticed with regular edges and pink surface, which soon assumes the characteristic color, and upon which the most superficial layers of the epidermis are desquamating; at the periphery of the papule the desquamation is arrested, and here is seen a thickened epidermic border. The surface of the papule is smooth and circular.

In the papular eruptions generalized over the entire body the skin where they are situated often becomes so thick as to warrant the term papulo-tuberculous; they unite and form large bands; for example, upon the forehead—*corona veneris*—or surround the mouth and alæ of the nose; they also form circles upon the shoulders, neck, and trunk, and extend over the surface of the limbs. Often, during the period of acme, they are covered with thick scales, which may be removed in irregular fragments by scratching; this form is termed *papulo-squamous*. Their color is always very distinct, intense, deep copper-red.

The essential **histological changes** which enter into the formation of a syphilitic papule are a hypertrophy of the papillæ of the skin, an increase in the number of epithelial layers which form the epidermis, and a proliferation of the cells of the rete mucosum. The blood-vessels are congested, and there occurs an extravasation of the blood-elements into the tissue of the derm which gives the characteristic coloration to the lesion. Desquamation of the superficial layers of the skin is one of the features of the papule. The changes are not limited to the papillæ and superficial corium, but in some varieties extend to the subcutaneous adipose tissue. There is no vascular sclerosis comparable to that met with in the chancre. These changes are modified by situation, duration, etc.

The **diagnosis** of a large papular syphilide is never very difficult. The special color and the arrangement of the papules, the involvement of the palms of the hands and soles of the feet, also of the palmar surface of the fingers and plantar surface of the toes, the enlargement of the lymphatic glands, the frequent existence of mucous patches, are all characteristic. The papular syphilide is indeed the most distinctive of all, and the most common after roseola. It is seldom that a syphilide with large papules continues less than two months, and frequently it remains three, four, or five months, especially if mercurial treatment has not been employed at all or too timidly. There is no form of medical treatment in which the curative power of a remedy is so evident and so admirable as in the use of mercury in cutaneous syphilides, and particularly in the severe forms of papulo-squamous eruption.

Mucous Patches.—A transformation of a syphilitic papule into a mucous patch takes place whenever it is under the continuous influence of warmth, moisture, and friction, as on a mucous membrane at a muco-cutaneous junction or in the creases or folds of skin. Under these circumstances the overlying epidermis or epithelium is macerated and disappears; the papule, originally small, rapidly extends in superficial area; it becomes grayish or opalescent in appearance if seated on a mucous surface; red, smooth, and polished if on the skin. In either case it is moist and has a free secretion, often offensive, and always highly contagious.

The most common seats of mucous patches are, first, in the order of their frequency, the genital organs and region of the anus. Their location varies according to the sex. With women mucous patches of the labia and of the

vulva are almost constant; with men, on the contrary, they are not very frequently met with on the prepuce or glans, the most common seats being the scrotum and anus. With women the anus is also frequently the seat of mucous patches.

The *histological structure* of mucous patches consists in a thickening of the epidermic layers and an increase in the size of the papillæ of the skin by a development of the elements entering into their structure. This increase in size of the papillæ causes a corresponding increase in the length of the inter-papillary prolongations of cells of the rete mucosum. The blood-vessels of the papillæ are distended with blood. The tissue of the derm is found proliferating.

Diagnosis of Mucous Patches.—It is almost impossible to mistake a mucous patch after a number have been seen. They are formed upon a papule—that is, an inflammatory swelling of the corium and papillæ; their surface is oozing, and the epidermis or epithelium which covers them is saturated or desquamated. Thus, upon the labia majora and minora there are seen whitish patches or small points which resemble moist or pulpy paper, and consist of epidermic cells or changed superficial epithelium; upon a mucous membrane, as on the lips or palate, the epithelium is whitish, opaline, resembling a surface which has been touched with nitrate of silver. The mucous patch, if eroded, has a surface which is red and smooth after the superficial epithelium has desquamated; the shape of the patch is always circular or regularly oval, and the derm is thickened upon its surface. The patches of the vulva and labia majora, likewise of the anus and of the scrotum and scrotal folds, even when in process of healing are very distinct; as the epidermis forms, the derm remains a little papular and the surface dull red.

The syphilitic papules, covered with thick superficial layers of corneous epidermis—that is, with scales—are termed **papulo-squamous syphilides**. They are generally very obstinate, since the layers of the epidermis repose upon the thickened and chronically inflamed derm. These squamous papules, covered with or deprived of their epidermic layers, when situated upon the palms of the hands and soles of the feet, are called **palmar** or **plantar syphilides**. The papules are modified simply on account of their seat and the structure of the skin of the hands and feet. Here the corneous epidermis attains considerable thickness and resistance; it forms a layer which at times measures a millimeter in thickness and is dense and hard like parchment. Thus it offers more or less resistance to the development of the papules, especially at their beginning. Later, however, the epidermis covering the papule is raised, cracked, and partly or completely eliminated, or it forms hard and irregular stratifications.

With syphilitic papules, and at the same time with secondary syphilides, there occurs a lesion allied to the lesions of the epidermis—viz. the changes of the nails.

Syphilitic Onychia is a disease of the nails, the peculiarities of which result from the anatomical structure of the matrix of the nail and of the peri- and subungual papillo-epidermic tissue. There are described two varieties—the dry and the moist.

The *dry* variety of onychia generally accompanies the papular and papulo-squamous eruptions situated upon the fingers and toes, the ends of which are attacked by papules, which pass around their extremities or may be seated at the roots and edges of the nails or under them. Sometimes the nail is cracked and readily broken; it is dry and separated from the skin. Sometimes, when the papules exist at the unguis matrix, there is a swelling of the skin at this region,

and the formation of the epidermic layers of the nail is very much interfered with. At times there is an irregular thickening of the nail by hard scabs, which are stratified and occasion a dense, irregular elevation.

The *moist* variety of onychia occurs with vesiculo-pustular or pustular syphilides. Sometimes true whitlow is met with.

These conditions often terminate in the destruction of the nail, and necessitate rest, antiseptic fomentations, and afterward some simple dressing.

Pustular Syphilides.—The pustular syphilide is found in the form of acne, of impetigo, or of ecthyma. Syphilitic acne is always early and superficial. Impetigo and ecthyma may also occur in the first stages and without any element of gravity, but in other cases, where they appear very early, may be of graver import; during the later eruptions they assume a still more serious aspect, and tend to rapid extension both in depth and superficial area, resulting in pustulo-crustaceous ulcers, of long duration and of extent corresponding to the amount of suppuration and the tendency to confluence of the lesions, which are often accompanied by symptoms of general cachexia, and in exceptional cases even terminate in death.

Syphilitic acne is as much a papule as a pustule in its structure and evolution. It forms a small conical projection, upon the top of which appears a very slight epidermic elevation, caused by a small quantity of serous effusion, which rapidly becomes purulent. The pustule is of short duration, and is soon replaced by a little crust, and then by scales, leaving only a stain, without cicatrix. This eruption appears in successive crops upon the face, the shoulders, the trunk, and thighs, in which latter situation the pustules are often confluent. There are generally at least as many papules or papulo-squamous spots as well-formed pustules, the papular elevation remaining after all traces of the pustule have disappeared from its summit. It is an eruption of the early stages, and behaves like the papular syphilide. It is distinguished from acne vulgaris by its distribution—for it especially affects the belly and thighs, while acne vulgaris is found on the face and shoulders—by its copper color and its greater dryness, and by the absence of white permanent cicatrices.

Syphilitic impetigo appears in the form of little pustules covered by crusts and resembling isolated pimples, or as patches formed by the union of many pustules. The pustulo-crustaceous form is commonly found upon the scalp at the same time that a syphilitic roseola or mucous patches have invaded the general integumental surface.

The impetigo may be the predominant eruption, the scalp, face, and forehead being the points of election. The reason for the transformation of a papular syphilide into the pustulo-crustaceous form upon the face and scalp is found in the abundance of sebaceous glands with which those parts are supplied. These glands, when involved in the inflammatory action, produce a papule; upon the cutaneous surface their secretion is modified, and consists then of a sebaceous liquid more or less intermingled with blood-corpuscles. As a result there is seen either a well-formed pustule, a sebaceous concretion, or a crust upon the surface of the papule.

Usually the pustules are seated upon a reddish, copper-colored patch or papule. When the eruption is confluent it covers large surfaces with scabs.

Syphilitic ecthyma may be superficial or deep. The former variety occurs usually on the lower limbs, and appears as a large pustule with a thick dark crust. It leaves behind it ecchymotic stains.

Deep ecthyma at first appears as a collection of pus under a large elevation of superficial epidermis, as occurs in the variety already described. The pustule is regularly circular; the contents inspissate by evaporation, and form a

crust which increases by the addition of successive layers. These crusts in superimposed strata, greenish or brown in hue, imbricated like the shell of an oyster, dry, resistant, are also met with in rupia, having the same configuration and immediately suggesting syphilis. Under this crust, which continues to enlarge and thicken, the pustule itself extends in breadth and depth. The crust overlaps the border of the ulcer, or, when the latter is the larger, is set within it like a watch-crystal in its case. When it falls off there is disclosed an ulceration extending to the papillæ or even deeper into the skin. These pustules are sometimes spread singly over a large portion of the body, most frequently the inferior extremities; in other cases they are grouped in the form of circles or crescents.

The **diagnosis** of syphilitic ecthyma from scrofulous ecthyma is frequently difficult. The latter ulceration is often deep and with perpendicular borders, as in the syphilides; the crusts, however, in syphilis are drier, darker, and more imbricated, the cachectic lesion suppurating earlier and more freely, consequently permitting of less adhesion of the crusts. This is not an invariable distinction, as in certain cases syphilitic ulcerations are attended with the formation of large quantities of pus. When the eruption is distributed upon the face and body as well as upon the limbs, the diagnosis of syphilis should be made, as the ecthyma due to scrofula is observed only upon the inferior extremities.

The history and concomitant symptoms almost always lead to a recognition of the disease, as it is a persistent eruption, lasting for months or even for a year, and often reappearing with all its original characteristics. It necessitates a guarded prognosis on account of its persistence and of the continual suppuration caused by it, especially when it is widespread. It is formidable also because it indicates a grave form of syphilis, particularly when it appears soon after the initial lesion.

Rupia manifests itself at first by large elevations of the epidermis filled with a clear or bloodstained serum, soon becoming turbid and purulent. The bulla bursts, allows some of the liquid to escape, and as it desiccates is covered with a crust, which dries, accumulates new layers, and becomes imbricated with brown and greenish strata, as in the variety of ecthyma just described. Rupia is, of all the syphilides, the one attended with the largest, thickest, darkest, and most characteristic crusts, as it is also the one presenting the most extensive ulcerations. Under these crusts the papillary layer and the entire derm are undergoing suppuration, as in the last two eruptions considered.

In the **tubercles** and **gummata** of the skin are seen the latest and deepest manifestations of cutaneous syphilis.

Syphilitic tubercles and gummata have striking analogies. They appear at the same stage of syphilis, are of the same clinical import, and are caused by the same pathological changes; the chief distinction being that the tubercles are more superficial, only involve the derm, do not extend into the subcutaneous tissue, and give rise to a less abundant cellular infiltration.

Tubercular syphilides represent deep and enormously swollen papules, and are intermediate pathologically between the papule and the gumma. They appear as single, flattened pimples, attended with an induration of the entire skin, from the superficial epidermis to the deepest layer of the derm; they are sometimes solitary, sometimes in groups, and may be scanty or may be widely extended. Their favorite situation is upon the face, at the mucous outlets, upon the nose, ears, forehead, back, neck, and inferior extremities, especially the legs.

There are two varieties, the dry and the ulcerating. The dry tubercular

syphilide is usually copper-colored and covered with thick scales, almost crusts; there may be no ulceration, and healing may occur, with the production of a white or pigmented cicatrix, without any ulcerative process having taken place.

The ulcerative tubercular syphilides are more grave on account of the abundant suppuration caused by them. They may be isolated, but are usually in groups, often very extensive.

Histologically, gummata and tubercles consist essentially in the formation of embryonal cells, which in the former, the gummata, occupy a position deep in the derm, infiltrating all the tissues, and in some instances even involving the deeper structures, bone, cartilage, etc. The tubercles are similar in their histological structure, but are limited more particularly to the skin, not affecting the subcutaneous tissues.

The disease for which an ulcerating tubercular syphilide is most likely to be mistaken is lupus vulgaris, which is a cellular new-growth due to infection with the bacillus of tuberculosis, and results in various papular or tubercular patches which are usually followed by ulceration. It has no relation with syphilis, and should be carefully distinguished from it, as the treatment beneficial in one case is useless or absolutely harmful in the other. The main diagnostic points may be tabulated as follows:

Tubercular Syphilide.

Occurs chiefly among adults.

Considerable infiltration of skin.

Tubercles opaque and of a deep brownish-red color.

The characteristic ulcer produced in a month or two.

Ulcers usually distinct.

Ulcers deep and extensive.

Ulcers small, circular, punched out.

Secretion copious, sometimes offensive.

Crusts bulky, greenish.

Scales irregular in shape and attachment.

Cicatrices soft, white, circular.

History and concomitant symptoms of syphilis.

Local treatment ineffective. Internal specific treatment effects a cure.

Lupus Vulgaris.

Occurs commonly in young persons; when in adults there is often a history of a similar eruption in childhood.

Not so marked.

Tubercles often translucent and lighter in color.

The same amount of ulceration would require several months or even years for its development.

Ulcers apt to be confluent.

More superficial and involving smaller area.

No regular form or perpendicular edges.

Secretion slight, inoffensive.

Crusts thin and dark-colored.

Scales arranged more regularly, attached in the centre and loosened at the edges.

Cicatrices distorted, irregular, puckered.

No such history except as a coincidence.

Eruption disappears only under very active local treatment, as curetting, or under the influence of tuberculin.

Gummata of the skin make their appearance at variable intervals after the contraction of syphilis; sometimes very late—twenty or thirty years after the chancre—sometimes, on the contrary, very early, during the first year, or even in the first four or five months; this occurs in the grave and abnormal varieties of the disease; most frequently they develop three or four years after the chancre. The favorite localities are the face, scalp, shoulders, neck, arms, thighs, and legs, but they may appear in any region of the body.

Cutaneous gummata are inflammatory tumors of the subcutaneous tissue—the cellulo-adipose connective tissue—which terminate by discharging externally: they cause a loss of substance to great depths, more considerable in extent at the bottom than at the cutaneous orifice, the disintegrated tissue being slowly thrown off like the core of a furuncle.

In the development of a gumma there are *four periods*, which include the processes of *formation, softening, ulceration, and repair*. The first period

is of long duration, and, as the tumor is painless, the patient usually discovers it by chance as a rounded or slightly flattened nodule seated deeply beneath the skin, which latter is slightly raised. The nodule is movable in the subcutaneous tissue, is hard, consistent, and gives rise to no subjective symptoms. The tumor grows slowly until it acquires a volume varying from one centimeter in diameter to that of a hen's egg. Ordinarily it has a diameter of from one-half to three-quarters of an inch. The skin over the surface of the gumma remains normal, until suppuration begins. After a time the tumor softens, becomes doughy, and then fluctuation takes place. Soon the skin reddens, grows thin at the most prominent point, and is finally perforated. The small circular opening gives exit at first only to a small quantity of purulent or gummy liquid; an open gumma not resembling in the least a discharging abscess. The gumma does not at once empty itself when it is opened. The inflamed connective tissue adheres by its deeper portions to the subcutaneous cellular tissue, which is thrown off in the form of small sloughs. Granulations forming at the bottom soon fill the cavity, the solution of continuity is repaired, and cicatrization takes place. The resulting cicatrix is depressed, often adherent to the deeper tissues or to the bone itself.

The **clinical characteristics** of the group of cutaneous syphilides may be stated as follows:

1. General or constitutional symptoms are usually absent, with the exception of the syphilitic fever which precedes or accompanies the early eruptions.

2. Additional evidences of syphilis will usually be found, and should be carefully searched for—the chancre, its cicatrix or its induration, the buboes, sore throat, baldness, mucous patches, etc.—if an early eruption be in question; osteocopic pains, nodes, and other bone-lesions in the later stages.

3. The eruptions, especially the early ones, are apt to be polymorphous, or to present at the same time a variety of forms of cutaneous lesion, macules, papules, and pustules being usually intermingled. This is due to the chronic, slow evolution of the disease, which permits of the development of new symptoms during the gradual fading of previous ones.

4. The patches of eruption are apt to have a rounded or crescentic form, due to the anatomical arrangement of the cutaneous capillaries, and when seated upon the extremities occupy the side of flexion—the anterior surface of the forearm, the palm of the hand, the sole of the foot, etc.

5. The characteristic color of the syphilitic eruptions is a yellowish-red, usually described as “coppery.” Its peculiar dusky tint is due to the absence of the active hyperemia and arterial excitement which usually exist in the non-specific eruptions, the color of syphilides being the result of slow changes in the coloring matter of the blood which has exuded under pressure, and not the accompaniment of acute inflammation.

6. There is an absence of pain and itching which is very distinctive, and which is also due to the non-inflammatory character of the eruption. It is quite common to find patients who are not aware of the presence of an extensive syphiloderm until their attention is directed to it by the surgeon.

7. The early eruptions are superficial, general, and symmetrical, indicating by these characters the infection of the blood to which they are due. During their evolution the disease is transmissible by contagion.

8. The early eruptions are frequently scaly, the pressure of the cell-proliferation, which is always present, cutting off the supply of nutriment to the superficial epidermic layers, which accordingly dry, desiccate, and are exfoliated.

9. The scales are whitish, superficial, and usually not adherent, there being no plastic or inflammatory exudation to fasten them to the subjacent part.

10. The later eruptions are not contagious, are irregular in distribution, extend to the cutis vera or beneath it into the connective tissue, and are described as local lesions or as sequelæ following the acute or secondary stage, and due either to relapses in parts previously diseased or to new-growths resulting from changes effected by syphilis.

11. The later eruptions have thick, irregular, or imbricated crusts, often occur in groups, and leave scars even if no ulceration has occurred.

12. Ulcers resulting from the breaking down of syphilitic deposits have rough, abrupt edges, are irregularly crescentic or circular in shape, covered with an unhealthy greenish-yellow secretion, and, as a rule, are painless.

13. The cicatrices caused by syphilis are at first pigmented, then whitish, shining, rounded, or radiating, and depressed below the level of the surrounding surface; they often show very small apertures, the sites of pre-existing follicles.

14. The therapeutic test in all very doubtful cases is an extremely valuable one, although it should be necessary to resort to it only in extremely exceptional instances. The amenability of nearly all the cutaneous symptoms to well-directed specific treatment often renders this test very conclusive.

The tertiary lesions of the mucous membranes are characterized by growths occupying the deeper portion of the mucous membrane or extending beyond it, and by gummata identified with those just described. They are nearly always ulcerative, but are not covered by crusts, owing to the facility with which the accumulated secretions are detached from the surface. Thus, in cases where upon the skin there would be a scab, upon the mucous membrane there is found an ulcer discharging pus more or less freely. Like the deep syphilodermata, they are limited and localized, for, as the disease grows older, instead of being extended and superficial and symmetrical, it becomes limited to a special locality and deeply involves and destroys its tissues.

The most important mucous membranes affected by tertiary lesions are the tongue, soft palate, and pharynx.

Tertiary Syphilis of the Mouth.—The most important of the late manifestations of syphilis in this region are the gummata of the tongue, which may be either submucous or muscular in their origin.

The *submucous gummata* are of the size of a pea or a cherry-stone, single or multiple. They begin as small, hard tumors, and their softening, their discharge through a small aperture, their excavated appearance and characteristic base, do not differ from those of other gummata: this is also true of their duration and of their mode of healing.

The *muscular gummata* are larger: they may occupy either the lateral or median aspects of the tongue, or may affect its tip, its base, or its edges. They reach the size of a hazel-nut. They open by what is first a very narrow channel, which enlarges or extends in the direction of the muscular fibers.

In these affections of the tongue it is rare to find enlarged cervical or submaxillary lymphatic glands, and the same is true of gummata of the pharynx.

The *differential diagnosis* of syphilitic diseases of the tongue is one of some importance, especially in regard to non-syphilitic affections which simulate them. Gummata of the tongue may be mistaken only for tubercular ulcers or for epitheliomata. From tubercular ulcers it would be difficult, if not impossible, to make a diagnosis from the character of the ulcer alone. The sides and edges of ulcerating tubercles often show, however, a few small yellow points with opaque centers, which are tubercular granulations undergoing caseous degeneration. These latter are finally thrown off by ulceration, and are never seen in syphilis. The evolution of tubercles of the tongue is entirely different from that of gum-

mata. The gumma begins as a single mass, submucous or muscular in position, opening after a time by a contracted passage, ulcerating, and discharging like a furuncle and having a sloughing base. The tubercles, on the contrary, begin on the surface as small nodules. By the union of many of these a large, irregular ulcer is formed, slower in its evolution than a gumma. As it extends in depth there are successive eruptions of tubercles, too minute to be detected by the naked eye, and situated between the muscular fibers. The ulcer has jagged edges and usually suppurates less than the gumma. In cases of doubt the chest should be carefully examined, as pulmonary tuberculosis often exists at the same time. The family history may also aid in the decision.

Lingual epithelioma may always be detected by microscopic examination of the fragments of tissue from the cancerous ulceration, large pavement-cells and epidermic nests being found. In addition, the epithelioma never becomes stationary or recedes, that of the tongue being especially grave and rapid, often running its course and terminating in death in a year or eighteen months.

The diagnosis between ulcerating epithelioma of the tongue and ulcerating gumma of the tongue has been tabulated by Fournier, as follows :

Epithelioma.

Chiefly affects persons between fifty and seventy years of age.

Often a history of cancer in near relatives or ancestors.

No history of syphilis.

The appearance which has been described as "lingual psoriasis" often precedes the cancerous disease.

Is generally single and confined to one side.

Is sometimes found on the under surface of the tongue.

Begins as a hard swelling upon the surface of the organ, and ulcerates rapidly and superficially; sometimes begins as a fissure or ulcer, without previous swelling or induration.

Induration follows cancerous ulceration.

No cavity resembling that of an abscess.

Surface bleeds when touched or spontaneously.

Edges turned outward, with the border elevated, irregular.

Secretion profuse, offensive, irritating.

Lancinating pain, often darting toward the ear, thought to be pathognomonic.

Great disturbance of deglutition, mastication, speech, etc.

General cachexia supervenes.

Microscopic examination shows the characteristic ingrowing of the interpapillary epithelium, the large squamous cells, pearly bodies, and other histological peculiarities of epithelioma.

Submaxillary lymphatic glands progressively enlarged and indurated.

Specific treatment useless or harmful.

Gumma.

Is apt to occur at an earlier period of life.

No such history, as a rule.

Such history almost always obtainable.

Nothing which resembles this has been seen.

May be multiple and bilateral.

Never seen except upon the dorsum or side of the tongue.

Begins as a rounded mass beneath the surface, and then opens like a furuncle, leaving a hollow, deep ulcer.

Induration precedes ulceration.

An excavation like an abscess-cavity.

Ulcer covered by an irregular slough which does not bleed.

Edges abrupt, perpendicular, "punched out," sharply defined.

Secretion moderate, not so apt to be offensive.

Painless or nearly so.

Tongue much more mobile; functional troubles not so marked.

No cachexia.

The microscope shows an infiltration of the part by embryonal cells in various stages of granular degeneration.

Glands not involved, or, at the most, a little swollen and tender.

Specific treatment curative.

Gummata of the soft palate, or of the palatine arch, usually result in a perforation of the palatine bones, causing a communication between the oral and nasal cavities. These gummata are slow and insidious in their onset.

The patient experiences no pain or discomfort. The soft palate is red, thickened, and either nodular in its entirety or at one point. The induration and thickening may be felt with the finger.

If the patient be asked to utter sounds requiring the assistance of the soft palate for their production—*ah*, for example—whilst the throat is being examined, it will be seen that the palate is elevated incompletely or not at all.

The immobility of the palate is a valuable symptom, and, taken in conjunction with the induration, the thickening, and the prominence often presented by the gumma itself, permits of an early diagnosis, which it is especially important to make as soon as possible in order to avoid perforation. If the patient be left without treatment, the gumma ulcerates and discharges, and if it be of the kind above mentioned, involving both the anterior and posterior mucous surface, complete perforation of the palate will follow with great rapidity, often taking place in a single day or night.

A gumma of the soft palate does not invariably give rise to perforation, especially if mixed treatment (see p. 172) be at once commenced. It may affect only one surface of the palate, and then it will heal without interfering with function. There may be even a small but complete perforation at the moment of the evacuation of the gumma, which will entirely heal.

Syphilis of Muscles.—Muscular syphilis is rare; it may manifest itself by contraction due to myositis, which at first appears to be idiopathic, as it is not accompanied by tumors or changes in size or apparent lesions; in other cases gummata develop in the interior of the muscles.

Syphilitic contracture of the muscles is chiefly an affection of the muscles of the arm, and more particularly of the biceps. It appears about six months to a year after the chancre. The first symptom is a stiffness of the elbow. Gradually extension becomes more and more limited, and the forearm remains flexed upon the arm at an angle varying from a large obtuse angle to one quite acute. No tumors or inequalities of surface are discoverable: if the muscle be examined during forced extension, it is found prominent and like a tightly-drawn cord.

It has been denied that this affection has any essential relation to syphilis, and it has been attributed to rheumatism, to traumatism, and to other causes. The weight of evidence is, however, in favor of its syphilitic origin; nine out of ten cases observed by Mauriac had a distinct history of syphilis and were accompanied by unmistakable eruptions, chiefly papular and papulo-squamous. He believes it to be a subacute myositis. In every one of six cases reported by Notta syphilitic symptoms were present. In none of them was there any association with rheumatism.

Gummata of muscles have a more important significance than these simple contractures. They consist of tumors, often of considerable size, which may discharge externally, may give rise in various ways to serious results, and may even invade the cardiac muscles. The tongue appears to be the muscle most frequently affected, and those of the sides and nape of the neck are often involved. Murchison has recorded a case of gumma of the diaphragm. Sometimes, instead of distinct tumors, a general infiltration occurs. White has seen a case in which all the posterior cervical muscles, including the trapezius, were thus infiltrated. Mixed treatment effected a rapid cure.

Syphilis of the Bones.—Among the most important and most common late effects of syphilis are the osseous lesions, which are often of much gravity. Both in adults and in children affected with hereditary syphilis the order, the seat of the lesions, and even the anatomical condition of the diseased bones,

are so characteristic that the diagnosis of syphilis is rendered easy. Osseous syphilis is met with during any of the periods of the malady.

The determining cause of the osseous lesion and of its seat, in tertiary as in secondary syphilis, is generally some form of traumatism, which is usually slight, but frequently repeated at the same point. It is owing to this fact that the superficial bones, as the frontal bone, clavicle, sternum, radius, tibia, etc., are the most common seats of the disease. Only the lesions of adults are here referred to. In cases of infantile syphilis traumatism is not the determining cause; the active development of the bones sufficiently accounts for the localization of the disease.

The lesions of the bones from an anatomical point of view are very numerous, varying from simple periostitis and osteitis to gummata; their final consequences also vary from the development of exostoses to the formation of sequestræ in pus-cavities.

The following lesions may be successively described:

1. Simple osteo-periostitis.
2. Rarefying osteitis.
3. Intense rarefying osteo-myelitis or gummatous osteo-periostitis.

Then the consecutive lesions of these different states, which are: formative osteitis or eburnation, the exostoses, the necroses, and the sequestræ; and finally the osseous lesions of infantile syphilis. (See p. 180.)

1. **Syphilitic osteo-periostitis** does not differ materially from ordinary osteo-periostitis. Limited to the superficial layers of the bone and the periosteum, it most frequently occurs at the end of the secondary or in the tertiary period, attacking the tibia, clavicle, sternum, bones of the head, etc.

2. When the inflammation is more intense there occurs a **rarefying osteitis**. The subperiosteal inflammation extends into the Haversian canals; the subperiosteal tissue and the osseous marrow contain numerous small cells with transuded red blood-corpuscles. These elements are free, with a small amount of granular intercellular substance. The original bone is eroded or destroyed. This lesion, which is observed so often in diseases of the phalanges and short bones, is named *spina ventosa*. It is frequently a result of syphilis.

3. **Gummatous osteo-myelitis** and **gummatous osteo-periostitis** are nothing more than a rarefying osteitis in which the abundant subperiosteal embryonal tissue or the medullary tissue assumes the arrangement that is observed in the gummata. The lesions are seen in the form of tumors, varying in size and having a tendency to become caseous. Gumma of bone is thus merely a circumscribed osteo-periostitis with destruction of the osseous lamellæ by a rarefying osteitis. It is the localization and form of the lesion which give it its distinctive characters.

The histological changes of the osseous tissue, as met with in the various forms of syphilitic lesions of the bones, therefore resemble similar lesions due to other causes. In osteo-periostitis there is a proliferation of the cells within the Haversian canals or the medullary elements of the bone which causes an increase in the size of these canals, the marrow itself becoming embryonic in nature. A continuation of this same process in a more intense degree results in the absorption of the osseous tissue, an enlargement of the Haversian canals, an increase in the amount of embryonal marrow, or, in brief, a rarefying osteitis, which in syphilis constitutes a gumma; that is, a gumma of bone is a localized intense osteo-periostitis in which there is a destruction of the osseous trabeculæ by the formation of granulation or embryonal tissue, which later undergoes retrograde metamorphosis and absorption. The bone in which the gumma or rarefying osteitis has been developed after the absorption of the

gummatous tissue takes on reparative action, and there occurs a formative osteitis, in which there is a new formation of osseous tissue, the process resembling that of the physiological development of bone. This process continuing, there results a condensing osteitis of the part, in which the laminae surrounding the Haversian canals are increased to such an extent as finally to obliterate the lumina of the canals and cause a sclerosis or eburnation of the bone. An exostosis is nothing more than a slow formative osteitis, which results in the gradual addition of new osseous layers to the original bone; if the process becomes active there is produced an eburnation of the new-formed bone, or if very intense there occurs that form of osteitis known as rarefying, and if still more active there may even be a complete destruction of the new osseous tissue. It is thus seen that the several lesions occurring in bones, and due to syphilis, are, to a great extent, the continuation or stages of one process which varies in its intensity and results.

Symptoms of Syphilitic Osseous Lesions.—The osseous lesions of syphilis are not always recognized during life, but in ordinary cases, when subcutaneous bones are involved, the symptoms are well marked.

The essential symptoms of syphilitic osteo-periostitis are pain and swelling. The pain is peculiar in that it is more intense during the night than during the day. It is very acute at times. It prevents sleep, and by its persistence may become of considerable gravity. The slightest touch to the tumor causes exquisite suffering. After two or three days' treatment with iodide of potassium it is usually relieved and often is entirely removed.

The symptoms of syphilitic osteitis are very variable, depending upon the bone affected and its connections. They differ, of course, very much with the variations in form of the lesions, which, as has been explained, may vary from a simple swelling of the periosteum and bone to the suppuration and necrosis with fistulous tracts met with in intense gummatous osteo-periostitis.

The most simple and most frequent cases are those of osteo-periosteal tumors of the superficial bones—the tibia, clavicle, sternum, frontal bone, etc. The nodular swelling, the single or multiple nodes of differing size, and the special pain upon firm pressure or upon percussion, are all characteristic. The pain occurs spontaneously during the early part of the night, before retiring.

The periostoses of the clavicle are readily seen on account of the position of the bone, and most frequently are oval in shape, with their long axes parallel to the long axis of the bone.

Osteo-periostitis of the anterior surface of the sternum and of the bones of the cranium, when recent, generally appears as a flattened swelling, varying in size and of the shape of the segment of a sphere. It is then elastic to the touch, and may disappear under mixed treatment. Later, when an osseous formation is developed around its circumference, it feels hard at the margins, while its central part is relatively soft.

As regards bones in general, the differences between syphilitic and tubercular inflammations may be stated as follows:

Syphilitic Osteitis.

Syphilitic osteitis occurs in persons in varying physical conditions.
Begins most frequently in the periosteum.
Tends to the formation of new bone or to necrosis.
Is often unaccompanied with suppuration.
Does not involve neighboring articulations.
Frequent in bones of the cranium.

Tubercular Osteitis.

Osteitis of tuberculosis occurs in persons who have other symptoms of this disease.
Begins in the medulla.
Tends to disintegration of the parts.
Generally terminates in the formation of pus.
Apt to do so.
Almost never found in this situation.

Syphilitic Osteitis.

Histologically, consists of a relatively large mass of granulation-tissue.

In the majority of cases can be cured, or at least arrested, if taken in time, by judicious specific treatment.

Tubercular Osteitis.

Made up of a varying number of tubercle-granulations and surrounded by isolated granules.

We know of nothing short of operative interference which materially affects the course of this disease.

Syphilitic dactylitis occurs at various periods of the disease, and in two varieties. One of these appears usually in the late secondary stage, and involves chiefly the periosteum and the fibrous and integumentary tissues surrounding a joint. It is characterized by slow, almost painless, swelling and discoloration of the affected member. This is due to a gummatous infiltration, which, upon subsiding, leaves the finger or toe temporarily stiff, but not permanently disabled.

The second form is a specific osteo-myelitis with accompanying inflammation of the periosteum, and appears from five to fifteen years after the infection with syphilis. It is chiefly limited to the bones and periosteum, the integument being but seldom involved; erosion of the articular cartilages often takes place; the ligaments and the capsule become thickened, and the function of the joint is sometimes entirely lost.

The absence of acute symptoms in the subcutaneous variety enables us to diagnosticate it from paronychia, whitlow, and gout. Rheumatoid arthritis begins in the joints, is associated with other symptoms, deformity of the fingers comes on early in the disease, and the sheaths of the tendons are involved.

The second variety might be taken for enchondroma or exostosis, but these swellings involve only a limited portion of the bone, increase very slowly, and present dense, circumscribed tumors.

Syphilis of the Nervous System.—The **dura mater** is frequently the seat of tertiary syphilis, chiefly owing to its intimate connection with the cranial bones, toward which it bears the relation of a periosteal lining. The internal surface of this membrane, in contact with the pia mater and with the surface of the brain, is frequently attacked at the same time—an accident which manifests itself by various cerebral symptoms: intense cephalalgia, trembling, dulness, intellectual torpor, loss of memory, and coma.

Besides these peri-encephalic lesions, the pia mater, and even the brain-substance and the spinal cord, may be the seat of sclerosis or of gummata.

The **pia mater** presents two varieties of lesions: A chronic inflammation, followed by fibrous thickening and by adhesions to the surface of the brain; and gummata, lesions much more characteristic than the foregoing.

Cerebral gummata may be found in two forms:

1st. As large gummatous masses developed on the surface of the brain within the convolutions and in the gray substance or encroaching upon the white substance, and usually attacking the base, the cerebral peduncles, the pons Varolii, and the optic tract. They are also found upon the cerebellum and upon the superior surface of the cerebrum.

2d. In the form of smaller nodules accompanying the cerebral arteries, and in particular the middle cerebral arteries.

These two varieties of syphilitic lesions do not differ materially as regards their structure; their evolution is slightly different. The latter are generally accompanied by endarteritis, which results in a limited anemic softening of the brain.

Symptoms of Cerebral Syphilis.—The symptoms depending upon the

different alterations of the meninges, of the brain, and of the vessels differ, it is needless to say, according to the region of the brain which is affected by them. The lesions of the dura mater, of the pia mater, and often those of the cranial bones, coincide with gummata or with more or less extended softening in such a manner that multiple manifestations have to be analyzed and explained. Despite these difficulties, the progress of these encephalopathies, a certain number of characteristics which appertain to them, and, in doubtful cases, the antecedents of the patients and trial of the iodide treatment, will ordinarily indicate their nature.

The most common initial phenomenon is headache, which is frontal, occipital, or parietal, very intense, often worse during the night, and accompanied frequently by vertigo and mental dulness, and sometimes by convulsions. This pain is at times intolerable, or, on the contrary, there may be a stupor resembling coma. The headache may last for a long time before any other symptom shows itself. If syphilis has been suspected from the antecedents of the patient, and iodide of potassium has been given with the result of lessening the pain or causing it to cease, the diagnosis is assured. During the headache the patients often experience a diminution of their intellectual faculties, forgetfulness of certain words or of their actions of the day before, etc. Different forms of paralysis supervene. They are at first very limited. The nerves at the base of the cranium are those most frequently attacked. The paralysis of muscles supplied by the common oculo-motor nerve produces, for example, external strabismus, diplopia, etc. The diminution of the sense of taste, and even its complete abolition, the loss of the sense of smell, the diminution or the loss of hearing, have also been noted. The disturbances of vision are exceedingly variable, and depend upon the seat of the lesion—whether it is localized in the cuneus, in the optic tracts before their intercrossing, at the optic chiasm, or upon the optic nerves beyond the chiasm. Subjective symptoms are observed, such as *muscæ volitantes*, circles of fire, etc., the perception of only a portion of objects, hemianopsia, or a partial or total loss of vision. These conditions are frequently cured by iodide of potassium.

The partial paralysis first shows itself in a limb—in the lower extremity of one side, for example—and is followed by amelioration if iodide of potassium employed in time has produced its curative action; if the lesion continues its progress, complete hemiplegia may supervene. This is generally progressive, slow at the commencement, with incomplete aphasia, especially if the paralysis is on the right side. These cases of hemiplegia are not accompanied, like those of copious hemorrhages or of apoplectic softening, by a total loss of consciousness. Patients preserve, on the contrary, to a great extent, their consciousness, as is the case in certain forms of cerebral softening, and the paralysis affects only the power of motion. Finally, along with several other phenomena connected with the intelligence or the power of motion, convulsive symptoms often predominate—veritable attacks of epilepsy.

The diagnosis of cerebral syphilis is based less upon the symptoms taken singly or in groups than upon the progress of the affection and upon the therapeutic action of iodide of potassium. An intense headache of long duration, which is cured or benefited by the iodide, but relapses, and which is accompanied by loss of memory, hebetude, slight paralysis; then a paralysis very slow in progress, ending in hemiplegia, aphasia, and epileptiform convulsion,—such are the symptoms upon which the diagnosis is established. These symptoms are slow in showing themselves, and they grow more intense very gradually. At their commencement they are benefited or cured by the iodide of potassium. Each of them presents some characteristic peculiar to

syphilis in such a way that recognition of the cause is possible in the great majority of cases. The diagnosis from apoplexy and softening is generally easy. The sudden onset of an attack with absolute loss of consciousness and complete hemiplegia excludes the idea of syphilis. It is more easy to confuse it with chronic softening; but in syphilis there are the violence of the headache, the effects of the iodide, the epileptiform convulsions, and especially the presence of old syphilitic lesions. Cerebral tumors are easily confounded with syphilis, but the consideration of cerebral tubercle is unnecessary, as it is an affection of infancy. Sarcomata might be mistaken for gummata; however, they are exceedingly rare, and the symptoms which characterize them are progressive, without its being possible to benefit them by the iodide treatment.

The **prognosis of cerebral syphilis** is very grave.

Syphilis, when it affects the **spinal cord**, may involve the meninges by a specific pachymeningitis, or the cord itself may be invaded by gummata originating either in its substance or in the membranes. The symptoms are those connected with pressure upon or degeneration of the cord itself, and the diagnosis is to be made chiefly by the presence of concomitant lesions of syphilis or by the effects of treatment. The interesting question of the relation of locomotor ataxia to syphilis is not yet settled, but there is enough evidence to justify the following recommendations:

In every case of ataxia careful and minute search should be made for evidences of antecedent syphilis, either acquired or inherited. If this be found to have existed, the patient should be placed at once upon vigorous specific treatment, and should be directed to continue it through long periods. If only a fair presumption of previous syphilis exist, the same treatment should be employed, as it would, at the most, be useless, but not hurtful. If the disease be recognized in its earliest stages, and found to be associated with syphilis, and treated in this manner, a prognosis may safely be given of a more favorable character than at present seems justifiable in any other variety or under any other mode of treatment.

Unlike cerebral syphilis, in which the question of operative treatment is often discussed, **syphilis of the intestinal tract** in the adult has little interest for the surgeon. The involvement of the liver, and especially that of the spleen, in newborn children are of great diagnostic importance, but will be fully considered in the chapter on Hereditary Syphilis.

Syphilis of the respiratory tract is of greater surgical interest and importance, on account of its relation to the larynx, where it may simulate carcinoma or tubercle.

Some help in the diagnosis of tertiary ulcers of the larynx from those of phthisis and cancer may be found in the points which have been tabulated as follows:

Syphilis.	Phthisis.	Cancer.
Development of ulcer acute, occupying only a few days.	Development slow; follows throat symptoms after several months.	Intermediate in time; appearance of ulcers in a few weeks.
Considerable irregular inflammatory or oedematous swelling.	Uniform, pale swelling, looking like an infiltration.	Nodular excrescences and acute inflammation of neighboring mucous membrane.
Epiglottis affected, if at all, on upper surface.	Lower surface.	No uniformity.
Ulcer solitary; rarely more than two.	Numerous.	Solitary.

Syphilis.	Phthisis.	Cancer.
Proceeds from center to periphery, or from above downward.	The reverse is true.	Irregular in their course.
Deep, round, or oval.	Generally round.	Irregular in shape.
Diameter of 1 to 1½ centimeters.	2 or 3 millimeters.	2 or 3 millimeters.
No cachexia.	Phthisical appearance.	Cachexia.
Treatment usually highly beneficial.	Treatment has but very moderate effect.	No effect.

Syphilis of the Testicles.—Syphilitic lesions of the testicles may consist in gummatous nodules of the epididymis, which appear at the end of the secondary period, or later in orchitis, which may be either interstitial or gummatous. There is also a syphilitic interstitial orchitis of newborn children.

Gummata of the Epididymis.—Toward the end of the secondary period there is occasionally observed upon the epididymis a limited induration, generally at its head, varying in size from that of a bean to that of a walnut or larger, connected with the testicle, hard and indolent. More rarely it is situated upon the body of the epididymis. It may be uni- or bilateral. There is no accompanying affection of the tunica vaginalis or of the skin. The tumor very soon disappears under treatment by mercury and iodide of potassium.

Interstitial Orchitis.—Interstitial orchitis of the adult belongs to the period of the later tertiary lesions. It seldom occurs before the third year. It may affect one or both sides. The testicle is the seat of a chronic interstitial inflammation. The epididymis is seldom affected; if it be involved, it is its head that is changed. At the beginning of interstitial orchitis the gland is a little larger than normal, but its shape is retained. If the disease is not treated, the gland gradually atrophies, still remaining indurated. There is frequently a notable effusion into the tunica vaginalis, which is inflamed.

The following table clearly presents the main points of difference between syphilis, encephaloid carcinoma, and tubercle of the testicle:

Syphilitic Orchitis.	Encephaloid Carcinoma of Testicle.	Tubercular Orchitis.
Syphilitic history.	No history of any special condition.	Tubercular history.
Usually occurs at about twenty-five or thirty years of age.	Any age.	Not often seen after thirty.
Begins in the testicle.	Begins in the body of the organ.	Begins in the epididymis.
Is situated primarily in the connective tissue.	Begins by the deposit of small nodules in the seminiferous tubules.	Exists primarily in the tubules.
Tends to fibrous overgrowth.	Tends to formation of patches of softened, white, pulsataceous material.	Tends to fatty, caseous, or purulent degeneration.
Slow in its progress.	Rapid in its course.	Slow in its progress.
Skin of the scrotum rarely involved.	Skin of the scrotum finally involved.	Skin involved only just before the formation of abscess.
Ulceration or suppuration rare.	Ulceration and fungus common.	Suppuration common.
Fistulæ uncommon.	Fistulæ common.	Fistulæ common.
A feeling of great weight, with only such pain as results from dragging on the cord.	Pain severe and lancinating in advanced stages.	Little pain.

Syphilitic Orchitis.	Encephaloid Carcinoma of Testicle.	Tubercular Orchitis.
Tumor very hard, uniform.	Soft and fluctuating.	At first hard, knotty, irregular.
Skin of scrotum purplish, but unaffected.	Network of large veins over surface of tumor.	Skin congested, but otherwise unaffected.
Of moderate size; rarely exceeds twice its normal diameter.	Attains great size.	Of moderate size.
Painless on pressure.	Painless on pressure.	Often painful on pressure.
Both testicles often affected.	Generally only one testicle affected.	Often both testicles affected.
Fungus rare.	Fungus always present in advanced stages.	Fungus common.
No discharge or bleeding.	Bleeds freely; offensive discharge.	Not so apt to bleed; discharge not so offensive.
Lasts many years.	Rarely extends beyond twenty months.	Lasts several years.
Curable.	Usually fatal.	Generally incurable.
No involvement of inguinal glands as a rule.	Inguinal, iliac, and lumbar glands and cord affected.	Usually no inflammation of glands.

TREATMENT OF SYPHILIS.

The prejudice which for many years existed against the employment of mercurials in syphilis has largely disappeared. A careful and impartial review of the testimony as to the results of the mercurial and of the non-mercurial treatment of syphilis will prove convincingly the far superior efficacy of the former method. Without denying that certain cases of syphilis do well without any treatment or with simple attention to hygiene, diet, etc., or even while admitting that in the majority of instances at the present day the disease tends to a spontaneous cure, it may still be considered as well established that, without detriment to health, the probability of that cure can be increased and the duration of the active stage of the malady lessened by a careful administration of some form of mercury. Similar, though not quite so conclusive, evidence exists in favor of a continuous as opposed to an intermittent plan of treatment, although various circumstances may render the latter desirable. The reasons which have been advanced for the employment of mercury in syphilis are—

1. The clinical evidence of its usefulness in the control of early symptoms and the prevention of later developments.
2. Its "tonic" action, which, by counteracting the anemic tendencies of syphilis, lessens the severity of the disease.
3. Its action as a physiological antidote to the syphilitic poison, which it destroys probably through its antibacterial or germicidal power.
4. Its properties as a promoter of destructive metamorphosis and fatty degeneration, through which it renders possible the absorption and removal of the new cell-growth which causes the secondary symptoms.

With regard to the beneficial influence of the iodides in the later stages, a therapeutic fact established beyond all possibility of contradiction, a similar diversity of opinion as to their mode of action prevails. A tonic effect is again claimed as one of the causes of the good results obtained by the administration of these preparations. The views held as to their *modus operandi* will depend upon the particular theory of the tertiary stage which is adopted. However this may be, the clinical evidence is quite sufficient to justify the employment of these drugs, and the proper methods of administering them may be epitomized as follows, beginning with the appearance of the initial lesion:

1. Do not employ mercurial treatment until either by confrontation or by the development of constitutional symptoms the diagnosis of syphilis is assured.

Mercury always retards the appearance of the secondary symptoms, and sometimes prevents it altogether. As no venereal sore can with absolute certainty be pronounced syphilitic, it is unwise to add an element of uncertainty to the case by delaying indefinitely the outbreak of unmistakable symptoms. There is sufficient evidence to prove that the subsequent course of the case is not materially affected by this delay. 2. When the time has arrived for the administration of mercury, it is well to explain to the patient the necessity for long-continued treatment and to point out the risks of neglect. Having done this, in the majority of cases the most satisfactory method of giving the drug will be by the mouth, a useful preparation being the protiodide of mercury in pill form, in the dose of $\frac{1}{4}$ to $\frac{1}{3}$ of a grain, three or four times daily:

R $\bar{y}$. Hydrarg. iodid. vir., gr. xx;
 Confect. rosæ, q. s.
 M. et ft. pill. no. lx.

If these should disagree with the stomach and produce dyspeptic symptoms, or should give rise to colicky pains and diarrhea, from $\frac{1}{20}$ to $\frac{1}{12}$ gr. of opium may with advantage be added to each pill. At the same time a saturated solution of chlorate of potassium should be given as a mouth-wash, to be used twice daily as a prophylactic against salivation. 3. To ascertain the proper dose of the drug in each individual case, continue gradually to increase the dose until slight tenderness of the gums or of the posterior molars is noticed. Then diminish it to two-thirds, or even to one-half, of that dose, when its further administration for an indefinite period will be possible with no unpleasant results. 4. If the preparation selected agrees with the patient and controls the symptoms, and if there are no intercurrent complications, pursue this treatment continuously for two years. If, however, the protiodide gives rise to persistent bowel trouble, as it does in a small number of cases, substitute for it the bichloride in solution or in combination with a tonic:

R $\bar{y}$. Hydrarg. chlorid. corros., gr. iss;
 Tinct. cinchonæ co., f $\bar{z}$ iv.
 M. et sig. One teaspoonful in water after meals.

Hydrargyrum cum creta in one-grain doses four to six times daily is a very useful preparation in cases of gastro-intestinal irritability. A half-grain to a grain of Dover's powder added to each dose will often control any tendency to diarrhea. In some cases of irritable stomach, or when it becomes desirable to intensify the mercurial influence, *inunction* should be employed, and it is a useful addition to the routine treatment of every case of syphilis. If once in six weeks or two months the administration of mercury by the mouth be intermitted and a dram of mercurial ointment rubbed into different portions of the cutaneous surface once daily for a week, it intensifies the mercurial influence without affecting digestion or nutrition. The uncleanness of the procedure and the almost certain eczematous irritation of the skin which it produces render it unsuitable for long-continued use. *Vapor baths* of mercury may be taken in various ways, the simplest being the volatilization by means of an alcohol lamp of a dram of calomel, the apparatus being placed beneath a chair upon which the patient sits, a blanket extending from his shoulders to the ground serving to retain the fumes in contact with his body. 5. By whatever method the mercurial influence is kept up, the dose should be temporarily raised whenever new

symptoms make their appearance, and, after they have vanished, should be dropped to the standard dose for the particular patient. 6. The local treatment of symptoms is of secondary importance, and altogether subservient to the constitutional treatment. It may, however, be useful as an adjuvant. Mucous patches should be treated with sulphate of copper or nitrate of silver if on mucous membranes; when on cutaneous surfaces they should be dusted with powder of starch and calomel or of calomel and lycopodium. The scaly and tubercular syphilides will be benefited by the application of a salve consisting of equal parts of citrine ointment and cosmoline, or by ammoniated mercury and cosmoline, two drams to the ounce, or by any other stimulating and absorbent ointment. Ulcers may be dressed with iodoform, or, when sluggish, touched with nitrate of silver or acid nitrate of mercury. Enlarged glands may be painted with iodine or let alone; they rarely run on to supuration. 7. At the end of two years small doses of iodide of potassium should be added to the mercurial, and this "mixed treatment" should be persevered in for six months longer. If during this period any symptom of syphilis makes its appearance, the six months of mixed treatment should be dated from that time. In other words, some such formula as this:

R Hydrarg. biniodid., gr. ij;
 Potass. iodid., ʒij;
 Syr. sarsaparillæ co.
 Aquæ, āā. f ʒiij.

M. et sig. A dessertspoonful in water after each meal,

should be administered for the last six months of the treatment, and should be recommenced and continued for six months if any symptoms appear later. Great care should be taken to give the mixture largely diluted, and so to vary it as to do away as far as possible with any irritation of the intestinal tract. In obstinate tertiary conditions the dose of the iodide may with impunity be run up to twenty, thirty, or sixty grains, or even more, four times daily. If this be done, the cases which refuse to come under its control will be very rare. 8. At the end of two and a half years the patient should be kept under observation for another full year, and if during that time no symptoms are developed, he may consider himself as in all probability cured. If such symptoms do appear, however, he should recommence treatment, and should continue it for at least six months after their subsidence.

CHAPTER XVIII.

HEREDITARY SYPHILIS.

THE most important points bearing upon the general subject of hereditary syphilis may be enumerated as follows:

I. Is syphilis transmissible in all its stages (*a*) to the wife or husband, or (*b*) to the offspring? In other words, is it ever proper to consent to the marriage of a person who has had syphilis? If so, under what circumstances?

II. By what means or through what channels can the disease of the parents reach the child?

III. What are the pathology and symptoms of hereditary syphilis?

IV. What is the treatment—(a) prophylactic, applied to the parents, (b) curative? We shall take these up seriatim.

I. Is Syphilis Transmissible in All its Stages?—No more important questions can be submitted to the surgeon than those pertaining to the marriage of syphilitics. Involving as it does the welfare of many individuals, modifying or fixing the conditions of one or more lives, his opinion should be exceptionally definite and well grounded.

There are two distinct methods of arriving at an answer to the question under discussion: First, by considering the probabilities in regard to the essential nature of syphilis; and second, by carefully weighing the clinical evidence in the matter. It seems evident that belief in any particular theory of syphilis, assigning it to this or that class of disease, must have an important influence in determining the opinion which is held as to its curability, or, at least, as to its indefinite transmissibility.

In regard to the first, the main point is the recognition of the fact that modern syphilographers, as a rule, regard the tertiary or late symptoms as indicative of damage done during the active period—as relapses or sequelæ, and not as fresh outbreaks of a highly contagious and transmissible disease. Their time of appearance, their entire want of symmetry, their non-contagiousness, their non-inoculability, all favor this view, and much corroborative evidence may be obtained from clinical facts.

It is necessary to admit that there seems to have been but little doubt in the minds of many syphilographers that in rare instances syphilitic children have been born to parents who had long passed the limits of the secondary period. At least, the majority of writers upon this subject speak confidently of the exceptional occurrence of such cases, and assert that syphilis may be transmitted during any of its stages. If, however, we look for positive evidence in this respect, we shall find very little that is entirely satisfactory. Cases are reported, to be sure, in which eight, ten, twelve, or even fifteen or twenty years after the primary sore, syphilitic patients have become the parents of children who showed unmistakable indications of the disease. When we examine the history of these cases, we find usually that many important points have been omitted without which it is impossible to be certain of their true character. Were both parents originally affected? If not, has a recent case of syphilis occurred in the one who at first escaped? If they were both diseased originally, has either been subsequently re-infected?—a much more frequent accident than has been commonly supposed. On applying these tests it will be found that few if any are thoroughly convincing.

Fournier, whose immense experience and acuteness of observation entitle his opinion to the utmost consideration, says that in cases of paternal heredity the duration of the power of transmission never exceeds, at the maximum, three or four years. Of the many hundreds he has observed, in no case has he known a syphilitic father to infect a child—the mother being healthy—at a later period than the one mentioned. And he is equally positive that the gradual diminution and final extinction of the syphilitic reaction of the parents upon the children constitute a veritable pathological law, “absolutely demonstrated.” Mr. Hutchinson says: “It is almost an acknowledged law that parents in the late tertiary stages do not transmit taint.”

These quotations indicate what is now the prevailing view—viz. that the period of transmissibility of syphilis is more or less strictly limited even when the disease is allowed to progress without treatment. As to the fact that it becomes milder with time, so that with each succeeding year after the termination of the secondary period the chances of escape of the product of conception

increase in a rapidly augmenting ratio, there is no difference of opinion whatever. Neither is it seriously disputed that the length of time during which the disease remains active, as well as the degree of its activity, may be markedly influenced by treatment. Under proper medication patients who have married in the height of the secondary period have had children born healthy who never subsequently manifested any symptoms of the disease.

We may therefore assume safely that syphilis after a certain period, not extending much over four years where the disease is allowed to run its own course, and probably somewhat reduced by treatment, ceases to be a contagious disease, and at about the same time or somewhat later loses, in the majority of cases, its capability of being transmitted by parent to offspring. As there are probably exceptions to the rule that this power of transmission disappears spontaneously within any specified time, it is never safe to trust altogether to nature, but a vigorous and sufficient specific treatment must be employed.

Given, however, the lapse of a sufficient time—say from three to four years as a minimum—and the history of a proper and continuous plan of treatment, the risks of marriage are so reduced as to warrant a careful surgeon in permitting it. And, conversely, of course in any doubtful case where such a history can be elicited, and where all these precautions have been observed, it is improbable that any taint of syphilis has been transmitted. Beyond this in positiveness it is not safe to go. There may be exceptions to these as to most other hygienic or therapeutic rules, but they will be of excessive rarity.

Before considering the methods by which syphilis can reach the child from one or the other of its parents, it may be well to mention the modes in which the parents can infect each other.

The *man* can derive syphilis from the *woman* only in the usual way—*i. e.* by contagion through a breach of surface permitting of the direct absorption of the poison, the development of the disease being attended by the usual phenomena—chancre, lymphatic enlargement, skin eruptions, etc. The *woman* may—and in the majority of cases does—acquire the disease from the *man* in a similar manner. But the *mother* may also become infected through the medium of the child, which receives its syphilis directly from the father, the mother up to the time of conception having escaped contagion. More than this, it appears to be highly probable that no woman ever bears a syphilitic child and remains herself absolutely free from the disease.

No surgeon of large experience in this class of cases can fail to have seen some in which the husband, having had syphilis and having married after an insufficient interval or an imperfect course of treatment, has infected his wife with the disease, although at the time no discoverable symptom is to be found upon his body. An equally careful inspection of the woman will also in such cases be attended by negative results as regards the primary sore, and yet she will be found with unmistakable evidences of constitutional syphilis. There is a clue to all such cases which will immediately resolve the difficulty. In every instance, provided that no mistake has been made and that both husband and wife are really free, the one from any contagious lesion, the other from any evidence of a present or previous primary sore, it will be found that pregnancy has occurred; that the woman has either been delivered of a syphilitic child or has had an abortion or miscarriage at some time before the outbreak of the symptoms of syphilis. Another argument lies in the application to the case in question of the well-known “law of Colles,” which, from the date of its first enunciation in 1837 down to the present day, has been found to be absolutely without exception. It may be given in his own words: “One fact well deserving our attention is this: that a child born of a mother who is

without obvious venereal symptoms, and which, without being exposed to any infection subsequent to its birth, shows this disease when a few weeks old,—this child will infect the most healthy nurse, whether she suckle it or merely handle and dress it; and yet this child is never known to infect its own mother, even though she suckle it while it has venereal ulcers of the lips and tongue.” As to the absolute and unvarying truth of this law there is not a shadow of doubt. There can be but one rational explanation of these facts—viz. that the mothers who have thus acquired immunity have done so by first acquiring the disease through pregnancy.

We may conclude, then, that the husband may infect his wife—(1) In the usual manner or by direct contagion; (2) through the medium of the child, or at any rate by the production of conception.

There is no proof whatever that the *semen of a syphilitic man* is contagious or can transmit the disease in any way but that above discussed. On the contrary, it has been shown experimentally that it is entirely non-inoculable. All other theories as to methods of contagion are so entirely hypothetical and unsupported by trustworthy evidence that we can afford to disregard them.

II. We may now consider the ways by which syphilis reaches the child. These may be broadly classified into—

1. Descent from the father; 2. Descent from the mother; 3 Direct infection.

As a matter of course, the influence of the father upon the child, so far as regards heredity, ceases at the moment of conception, or, to be more exact, no subsequent condition of the male parent, no development or acquirement of disease, can exert any further effect. That the existence of active syphilis in the father may result in the transmission of the malady to the child cannot be doubted. The relative effect of paternal as compared with maternal influence may be considered after we have described the latter.

2. Descent from the mother may occur theoretically in consequence of—

a. Infection of the mother previous to conception; *b.* Infection of the mother at the moment of conception; *c.* Infection of the mother during the period of utero-gestation.

a. As to the first of these methods of transmitting the disease there is little if any difference of opinion. Even those who claim the most for paternal influence include among the conditions which may give rise to syphilis in the child disease of the ovule, and it may be stated as incontrovertible that recent or active syphilis in the mother at the time of conception will almost certainly be followed by syphilis in the child. The cases in which treatment of the father has resulted in healthy children, whereas without treatment he procreated syphilitic children, the mother being without either symptom or treatment, have been urged as evidence of the direct descent of syphilis from the father to the child without the intervention or participation of the mother. But it does not follow because the mother has latent or hidden syphilis that she must infect her child. In those cases in which she does not do so the treatment of the father will remove the only active source of syphilitic infection.

b. The second method, or that in which the mother becomes syphilitic at the moment of conception, is really, strictly speaking, an example of paternal heredity, as the resulting germ is syphilitic, not because the ovule of the mother was infected, but on account of the disease of the spermatozoid of the father.

c. There remains for consideration the influence upon the child of a syphilis acquired by the mother during some period of utero-gestation. That under

these circumstances the child can become infected has been and is still absolutely denied by some very respectable authorities. All that is necessary for proof of its occurrence is, however, (1) freedom of both parents from syphilis at the time of conception, or, in other words, syphilis must have been acquired by both—not alone by the mother—after the beginning of pregnancy; (2) that the syphilis of the child be unmistakably prenatal—that is, not acquired by some accident during or after birth. Several cases reported by acute observers seem to combine both these requisites, and, after reading them carefully, there seems to be no reasonable escape from the conclusion that in some manner the poison of syphilis may find its way from the mother to the child. The old idea that the latter was directly infected in utero from the semen of the father is, of course, altogether without foundation.

3. Direct infection of the child during birth does not properly come under the head of Hereditary Syphilis. There is no possible reason why, when the mother has contagious lesions of the genitals, acquired too late to infect the child in utero, this should not occur, but as a matter of fact no such case has ever been recorded. One explanation of this circumstance may be found in the protective covering of vernix and mucus which coats the infant's body and lessens greatly the risk of absorption. This hardly accounts satisfactorily, however, for the entire absence of such cases from medical literature, and it is fair to suppose that in all except those cases in which the primary sore is acquired during the last month of gestation—which for obvious reasons are excessively rare—the infant acquires some immunity which protects it from its mother, and is similar to that which, under Colles's law, operates in her favor. In other words, even though apparently free from syphilis at birth—a not uncommon event, as we shall see—it has a latent or modified syphilis which protects it from contagion. (Profeta's law, see p. 136.)

We may now briefly restate the conclusions at which we have arrived:

1. After a certain interval, not less than four years, and after thorough specific treatment, a person who has contracted a syphilis not especially severe or malignant in its type may be permitted to marry. The assent to marriage will then be based on a belief in the curability of syphilis or in a cessation of its contagiousness, its inoculability, and, in the vast majority of cases, its transmissive power, at the end of the secondary stage.

2. It may be inherited from either parent or from both, and the probability that this will occur increases in a direct ratio with the nearness of the time of conception to the date of their infection with the disease. The severity of the inherited disease in the child increases in the same proportion.

3. It is undoubted that, the father being healthy and the mother syphilitic, the child may, and in all probability will, have the disease.

4. It is probable, but less so than in the preceding case, that, the mother being healthy and the father syphilitic, the child will be infected.

5. It is highly probable that in all cases where a child becomes syphilitic through paternal influence the mother is also the subject of syphilis, which may, however, assume a latent form, the only evidence of its presence in a few cases being the protection which it affords against contagion through the medium of the child.

6. Syphilis may be transmitted from mother to child even when it is acquired by the former as late as the seventh month of utero-gestation.

III. The Pathology and Symptoms of Hereditary Syphilis.—*Syphilis of the placenta* is of especial interest in its relation to the abortions and stillbirths so frequent in syphilis. Under the influence of that disease cell-proliferation begins in the villi, which are, normally, only sparingly supplied with

cells, and extends to the connective-tissue stroma and the epithelium. This proceeds to such an extent that it leads to compression of the vessels, and finally obliterates them. The vascular spaces into which the villi dip become filled up and narrowed, and often disappear. In this way, and also by reason of the thickening of the epithelium, the interchange between the maternal and the foetal blood is interfered with, and at last is prevented. If this process is spread over the whole placenta, the foetus perishes before it is complete. If it is limited to circumscribed areas, it may continue to live for a shorter or longer period.

Syphilis in the parents will manifest itself in the children in one of several ways, which are determined chiefly by two factors—viz. first, the length of the interval between the infection of the parent and the date of conception; and, second, the thoroughness of the treatment of the parents during that interval. To these may be added as subsidiary, but still of definite importance, a third, the type of disease which has affected the father or the mother, whether mild or severe, benign or malignant.

From what has already been said in reference to the question of marriage, it will at once be understood that the danger to the offspring in untreated cases, and in those where conception has occurred during the early secondary period of the disease, is of extreme gravity. In such cases the usual result of pregnancy is abortion at from the first to the fifth or sixth month, the foetus sometimes exhibiting the evidences of syphilis in the shape of large bullæ upon the palms and soles, or in the presence of characteristic visceral lesions, but quite as often showing nothing distinctive. It has generally undergone more or less maceration, and the skin, which is readily detachable, is of a congested, purplish color. At least one-third of syphilitic children are dead-born. As time goes on and other pregnancies follow, either the abortion occurs at a later period of pregnancy or the children are brought alive into the world. Even then, however, and although at birth they may show no evidences of the disease, their chance of escape is but small. One-fourth of them die within the first six months. If they survive that period, the chances for life are slightly in their favor, but those for health or for freedom from deformity and disease are still overwhelmingly against them.

The Primary Stage is never found in true hereditary syphilis. Of course in congenital or infantile syphilis, in which by direct contagion, either from the mother or from any one else, the disease was acquired by the child, the course would not differ materially from that observed in the adult, and the primary sore would be present. But as this stage of acquired syphilis corresponds to the period during which the poison is finding its way into the system through the lymphatics, it is not found in the child who is infected from the moment of conception or who receives the poison from the mother directly into the circulation.

The Secondary Stage.—For from one to three weeks the newborn infant often shows no symptoms of the disease. In 158 cases collected by Diday, 86 manifested symptoms before the expiration of the first month, and 60 of the remainder before the end of the third month. When to these are added the statistics of Roger, we find that of a total of 172 cases 159 showed syphilitic symptoms before the end of the third month. When these symptoms are present at birth, they consist largely in a general withered, atrophied, weakened appearance of the child; a hoarse cry, due to swelling, with sub-acute inflammation, or even ulceration, of the laryngeal mucous membrane; a coryza, due to a similar condition of the Schneiderian membrane; and

certain cutaneous eruptions, the most common of which at this early date is the large vesicular or bullous eruption known as syphilitic pemphigus.

Pemphigus.—With regard to the specific or non-specific character of this eruption there has been much difference of opinion, and, as it is often the earliest distinctive expression of syphilis, a diagnosis of which could hardly be founded on the general appearance of the child, or even on the hoarse cry and the coryza, it becomes important to have definite ideas upon the subject. Nearly a century ago it was denied that this eruption was a manifestation of venereal disease; and this view has found supporters down to the present day. The progress of clinical and pathological knowledge enables us now to assert, however, that although, as an exception, bullæ may sometimes be due to a profound cachexia not dependent on syphilis, yet in the large majority of cases they are specific in their character.

If we find an infant at or immediately after birth presenting on the soles, the palms, the fingers and toes, or on the limbs an eruption consisting of blebs more or less perfectly distended with a liquid which may be clear, cloudy, or bloody, circular or oval in shape, sometimes irregular, seated on inflamed, reddish skin, and surrounded by trifling areolæ, we may strongly suspect the presence of syphilis in an active and most menacing form. And this suspicion becomes a certainty if, in combination with such an eruption, the general cutaneous surface is yellowish or muddy in hue, is hard and dry, without elasticity or softness—owing to the absence of subcutaneous fat—and, for the same reason, is furrowed and wrinkled about the face, imparting an appearance of senility; if the child has a hoarse cry, and a discharge from the nostrils; and, of course, if there are at the same time other syphilodermata. This eruption is specially important, however, because upon the recognition of its specific character in cases of stillbirth or in those in which the child survives only a few days—not long enough for the development of further symptoms—will depend the opinion as to the cause of death, which, whether expressed or not, will determine the future treatment of both parents during the interval between pregnancies and of the mother during the next pregnancy.

Coryza is one of the most characteristic, and at the same time one of the most important, of the early symptoms of syphilis in its influence on the health of the child. It is due to the same condition of the mucous membrane lining the nasal fossæ which manifests itself simultaneously or soon afterward on the skin in the shape of erythema, roseola, or papules; in other words, it is a hyperemia with papillary infiltration. The excessive supply of blood to the parts induces a catarrhal condition which shows itself in a thin, watery discharge. As the child during suckling is compelled to breathe through the nose, this discharge is rapidly dried into crusts, causing the peculiar nasal, noisy respiration which has given the affection the popular name of *snuffles*.

Roseola is apt to present itself about the second or third week after birth. As in the adult, it begins upon the abdomen in the form of little oval, circular, or irregular spots, dull red in color and disappearing upon pressure. Later the color becomes deeper, the eruption extends to the trunk and limbs, and, as exudation and cell-proliferation succeed to simple capillary stasis, it ceases to disappear when pressed upon. It is often moist, and sometimes excoriated, owing to the thinness of the epidermis. Occasionally it is confluent, and covers large areas with an almost unbroken sheet of deep-red color.

The *diagnosis* in the early stage is often difficult on account of the resemblance to the simple erythema of infancy. As the disease progresses, however, maculæ form here and there; the cell-infiltration involves the papillæ, several of which coalesce, forming flat papules; the nutrition of the superficial layers

of the epidermis is interfered with, especially where it is thick, as on the palms and soles, and the eruption in these regions becomes scaly: and then the diagnosis is not difficult.

Papules and Mucous Patches.—In the ordinary evolution of the disease the next manifestation is usually the development of papules on the general cutaneous surface and of mucous patches on the tongue, lips, and cheeks; probably also on other mucous membranes not exposed to examination. The papules for the reason already mentioned—the thinness and moisture of the skin—are apt to be of the broad, flat kind, especially, as in the adult, in those regions where the elements of warmth and friction are superadded to moisture, as in the folds of skin about the genitalia, the neck, the flexures of the joints, etc. They are then moist, covered with a grayish secretion or a thin crust, and are in reality mucous patches. Mucous patches in the infant are among the most important of the early syphilitic lesions, as they are almost constantly present, and *thus constitute by far the most frequent vehicle for conveying the disease from the child to its nurse or to others with whom it may come in contact.* No child that has even been suspected of having a taint of hereditary syphilis should be permitted to nurse at the breast of any one but the mother, or to share its cup or nursing-bottle with other children, or to receive the caresses of relatives or friends; and in this last restriction we should include the father. The mucous patches should be actively treated both locally and constitutionally, and during their demonstrable presence a most rigorous quarantine should be observed.

Syphilitic condylomata are due to hypertrophic changes in the papules, which under the influence of heat and moisture in certain regions coalesce and become more elevated. They vary in size from an eighth to a quarter, or even a half, of an inch in diameter. Their surface is flat and covered by a crust or by an offensive secretion. They are found most commonly about the anus or at the angles of the mouth.

Pustular Syphilides.—A little later in the secondary period, usually at about the sixth week, but sometimes much earlier, the papules may become transformed into pustules, the change taking place slowly.

Iritis.—Another symptom of the secondary period, but of later development and of rarer occurrence than the syphilodermata which have been described, is iritis. In spite of its rarity, this is extremely important, because it is frequently overlooked until it has reached such a stage that occlusion of the pupil results, and also because when it is recognized it constitutes an almost pathognomonic sign of syphilis.

If the condition is observed, the *diagnosis* is not usually difficult. The pupil is irregular, especially under atropine; there are streaks of lymph, dulness, swelling, and change of color, and on very careful inspection a faint pink zone may be seen in the sclerotic. The conjunctiva and cornea are generally clear.

The *prognosis* depends on the stage at which the patient comes under treatment. The lymph, if recent, no matter in what quantity, will probably be absorbed under mercurial treatment, which will often be of great benefit even in those cases in which a certain amount of organization has occurred.

The foregoing symptoms are characteristic of the secondary period of hereditary syphilis, or that extending from birth, or more commonly from the age of three or four weeks, to about the end of the first year. They may be again enumerated as follows: coryza with snuffles; an erythematous, papular, or pustular eruption on the skin; mucous patches on the lips, tongue, cheeks, etc.; a marked tendency to general wasting; a hoarse cry or cough;

senility of aspect; iritis. The majority of syphilitic children born alive die during this stage.

Before its termination, sometimes even at birth, other lesions have been noticed (especially those affecting the liver), which, however, may be better described in connection with the special organ or organs involved.

Succeeding this stage—*i. e.* beginning in about a year or eighteen months—comes an **intermediate period**, which extends to second dentition, to puberty, or even much later, and which is characterized rather negatively—that is, by the absence of symptoms—than otherwise. The evidence of the general diathesis will of course be present in the shape possibly of malnutrition, stunted growth, or retarded development, perhaps shown in the weazened or withered face, the sunken nose, the pallor of the skin, the premature loss of the first upper incisor teeth, or the malformation of the others if they have erupted.

There is but little tendency to recurrence or relapse of any of the secondary symptoms; and in certain cases this stage extends through life, or, in other words, as is frequently the case with the adult who has followed a proper course of treatment, the disease appears to terminate with the secondary stage. In other cases, however, it recurs, and the symptoms which it then presents may be taken up in connection with the different organs or tissues involved.

Syphilis of the ear is for obvious reasons not often discoverable until the patient has reached an age at which interference with the function of hearing becomes a noticeable phenomenon. The only symptom likely to be noticed during the stage of inherited syphilis which we are now considering is a catarrh of the middle ear. This may lead to perforation of the membrana tympani, purulent infiltration of the mastoid cells, etc., and when accompanied by an otorrhea which attracts attention to the ear will be easily discovered by the surgeon.

The affections of the middle ear and Eustachian tube are said to be contemporaneous with the keratitis which appears in the neighborhood of puberty, while those of the auditory nerve are somewhat later in point of time, and are almost always conjoined with retinitis, choroiditis, and optic neuritis.

Syphilitic disease of the liver in newborn children is distinguished especially by increase in size and weight of the organ. This increase depends upon a proliferation of cells from the connective tissue between the acini, or from the adventitia of the interlobular vessels, this growth becoming transformed into connective tissue. The change is quite analogous to that which is taking place at the same time in the skin, the mucous membranes, and other tissues. It does not, however, go on to organization, but may be just as susceptible of absorption and resolution as are the papules or maculæ of the skin. A portion of the enlargement may be due to a passive congestion caused by the presence of this cell-accumulation.

As to the diagnosis of hepatic syphilis in infants, the symptoms are indefinite, or they are identical with those often observed in children who have poor or insufficient nourishment. The only physical sign which properly belongs to hepatic syphilis, when it exists at all, is increase in the size of the liver.

Bone syphilis in children is essentially of the nature of the syphilitic bone troubles with which we are familiar in the acquired form of the disease, consisting primarily and throughout of an unnatural accumulation of cell-elements, which in the later stages by their pressure produce various degenerations of surrounding structures, and which, as they occur during the process of bone-formation, are accompanied by irregular and abnormal deposits of lime-salts. They especially affect the junctions of the epiphyses and diaphyses, because at that time those points are the seats of great physiological activity.

The *symptoms* which obtain in this condition of syphilitic osteochondritis are as follows. There is a swelling at the diaphyso-epiphyseal junction of one of the long bones, which in the emaciated subjects of hereditary syphilis is often visible and can always be discovered by palpation. This consists of a ring or collar which more or less completely surrounds the bone, is apt to be smooth rather than irregular, and, when two bones situated near to each other are simultaneously affected, may conjoin them. A moderate amount of synovitis is often present. This affects chiefly the elbow and the knee, but may appear in any joint. It is readily influenced by specific treatment and well-regulated pressure. When the last stage is reached, or that of the formation of granulation-tissue, with degenerative changes of the cartilages and of the bones themselves, deformity often becomes more marked. There are unnatural curves or angles in the bones, with more or less complete separation at the point of junction.

The most important *differential diagnosis* to be made in these cases is between the rhachitis of young children and the form of syphilis in question. The points of resemblance are manifest, just as they are between a syphilitic and a variolous pustule, but they end in both cases when we come to study the evolution of the phenomena either from an anatomical or from a clinical standpoint. They may be expressed as follows in tabular form:

Osseous Lesions due to Inherited Syphilis.	Rickets.
The swellings, particularly those of the long bones, show themselves at or soon after birth.	Rarely appear before six months, generally still later.
A history of syphilis or evidence of existing syphilis in one or both parents.	No such history necessarily.
Preceded or accompanied by snuffles, coryza, and cutaneous and mucous lesions.	No such prodromata.
No such prodromata in most cases.	Pallor, restlessness, sweating, nausea, diarrhea, etc. constitute a combination of symptoms which often precede the bone disease.
Cachexia absent or moderate.	Cachexia marked.
Physiognomical peculiarities of syphilis present.	Not present as a group.
Circumscribed tumors on frontal and parietal bones, rarely on occiput.	Cranial bones thickened in spots, usually upon the occiput.
Ribs not markedly affected.	All or nearly all involved.
Disease of ribs, when existent, not ordinarily coincident with that of other bones.	Nearly always so.
Fontanels close at usual period.	Closure delayed.
Other syphilitic symptoms present—enlargement of phalanges, metatarsal bones, etc.	Syphilitic symptoms absent.
Often accompanied by sinuses, synovitis, abscesses, cutaneous ulcers, etc.	Little external or surrounding involvement.
Generally disappears by resolution, without leaving any permanent change.	Usually leaves some bending of shaft and distortion of the neighboring joint.
Mortality among children in whom many bones are involved is very great.	Much less.
Specific treatment useful.	Of no benefit.
In the first stage there is an exuberant calcification of the ossifying cartilage, causing necrosis of the new-formed tissue and a consecutive inflammation, which terminates in the separation of the epiphyses. ¹	This is less marked. There is formed, instead, a soft and non-calcified osteoid tissue.

¹ This table is founded on one published in the translation of Cornil *On Syphilis*, by Drs. Simes and White, and is compiled chiefly from the excellent work of Dr. Taylor on this subject.

The bone lesions of hereditary exostosis can readily be recognized by the facts that they are stationary, appear later, and are of larger size, by the absence of syphilitic history or symptoms and by their resistance to specific treatment. The diagnosis from accidental separation of the epiphysis or from fractures may be made from the history of the case.

In cases of separation of the epiphysis, complicated with suppuration, sinuses, etc., the trouble may be mistaken for a similar condition due to non-specific inflammation. In all the recorded instances, however, the latter has occurred much later in life, is attended with much more acute inflammatory symptoms, lymphangitis, etc., and is of course without concomitant symptoms of syphilis. In both cases there is a decided osteo-periostitis, and, as so much depends on the early and vigorous use of specific treatment, it may be worth while to contrast the two forms of the disease.

Syphilitic Osteo-periostitis.

Occurs in infants under three months of age.

History of syphilis in child and its parents.

Implication of other bones.

Coincident with the development of the shaft of the bone.

Other lesions of syphilis—nodes, skin eruptions, etc.

All the local symptoms comparatively mild.

Disease sharply localized.

Lymphatics of limb unaffected.

Beneficial effect of specific treatment if employed early.

Non-specific Osteo-periostitis.

Seldom if ever occurs in children under one year of age.

No history of syphilis; sometimes a history of traumatism.

Usually confined to one bone.

Coexists with the ossification of the epiphyses.

No such symptoms.

Pain, redness, and swelling very marked.

Involves neighboring parts.

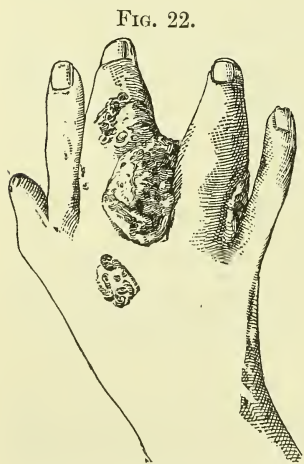
Lymphangitis sometimes present.

No such effect.

Syphilitic Dactylitis (Fig. 22) in the inherited variety of the disease, as in the acquired, consists of two varieties. The one of these which generally appears earlier affects chiefly the periosteum and the fibrous and integumentary structures surrounding a joint, usually a metacarpal- or metatarsal-phalangeal articulation, involving a phalanx, and is characterized by slow, almost painless, swelling and discoloration of the affected member. This is due to a gummatous infiltration, which, after absorption under proper treatment, leaves the toe or finger temporarily stiff, but not permanently disabled.

The second form is a specific osteo-myelitis, with periostitis, coming on later, and often destroying the bone or the articulation involved.

The absence of acute inflammatory symptoms in the first variety distinguishes it from paronychia, whitlow, and gout. Rheumatoid arthritis begins in the joints and is associated with other symptoms; deformity of the fingers comes early in the disease, and there is a teno-synovitis with contraction.



Ulcerated Syphilitic Dactylitis
(original).

The second variety might be taken for enchondroma or exostosis, but these growths increase much more slowly, involve only a limited portion of the bone, are of greater density, and are much more strictly circumscribed.

As a rule, especially in cases which are recognized early and treated actively, the *prognosis* is good.

Syphilis of the Teeth.—Syphilis of the teeth has its chief interest from its very important bearing on diagnosis. Manifesting itself at an age when the child is not apt to present the active and unmistakable cutaneous and mucous lesions of the disease, the recognition of which is therefore often extremely difficult, this diagnostic importance is greatly increased.

The teeth of the *first dentition*, although exhibiting the usual signs of interference with nutrition in their irregular development, opaque and chalky enamel deficient in quantity and unevenly distributed, soft and friable dentine, incongruity of size individually and relatively, and proneness to decay, do not often display any distinctive evidence of syphilis. The same conditions may, and often do, depend on other causes, and are commonly associated with various cachexiæ.

In the *permanent teeth*, likewise, the same condition may be due to the same causes. Stomatitis, however produced—by mercury, by gastro-intestinal derangements, by local irritation of any kind—is apt to result in imperfectly organized dental structures. Mercurial teeth, for example, are usually irregularly aligned, horizontally seamed, honeycombed, scraggy, malformed, of an unhealthy dirty-yellow color, separated too widely, and deficient in enamel. The diseases of childhood by temporarily arresting or greatly interfering with nutrition during the developmental period of the teeth often cause horizontal furrows across their crowns.

None of these conditions, however, are in the least degree characteristic of syphilis, the special expression of which in the mouth is to be found only in the *permanent upper median incisors*. It may be considered as well established that when these teeth are stunted, abnormally narrow at the cutting edge, crescentically rounded with the convexity upward, and the surface inclined upward and forward, instead of backward as in normal teeth, widely separated, but converging at their lower edges, they are pathognomonic of hereditary syphilis (Fig. 23). They are generally known as "*Hutchinson's teeth*." They are often described as pegged, having been likened to a row of pegs stuck in the gums. This appearance is due to the facts that they are shortened, often projecting not more than half the normal distance from the gum, and are also widely separated; which abnormalities often affect the adjoining teeth, and sometimes the entire denture. A mistake which is frequently made is the confusing of the serrations of the cutting edges of recently-erupted normal incisors (Fig. 24) with the peculiar crescentic edges of syphilitic teeth.

Interstitial Keratitis.—The frequency of this form of diffuse inflammation of the cornea, and the diagnostic significance which has been so positively attributed to it—and as positively denied—render it of special interest. It begins, commonly, as a slight, diffused haziness situated in the substance of the cornea itself, usually not far from the centre, and at first affecting only one eye. This condition may persist for one or two months, after which the other cornea is nearly always attacked, and is similarly affected, although the disease is apt to pass through its different stages rather more rapidly than in the first eye. When the height of the disease is reached the corneæ are nearly opaque, a bare perception of light remaining. Then the cornea which was first involved begins to clear; this is soon followed by improvement in the other one, which in the course of a year or two results in a return to fairly good sight,

FIG. 23.



Upper Median Incisors in Hereditary Syphilis (Cornil and Ranvier).

FIG. 24.



Serrations in Normal Teeth (Cornil and Ranvier).

although in most cases there remain a slight haziness and an abnormal expansion of the cornea.

The *diagnosis* of this condition may generally be made with ease. The ground-glass appearance in the earlier stages and the dull pink or salmon color in the more vascular stage are very characteristic. The vascularity differs from that attending other chronic forms of keratitis, granular lids, etc., in which the vessels are large and superficial: in syphilitic keratitis they are much deeper and very closely interwoven, so that the effect is almost that of an ecchymosis. In non-syphilitic cases both eyes are not so apt to be affected nor is the tendency to spontaneous cure so marked. The absence of ulceration and the very slight degree of accompanying sclerotic or ciliary congestion are also valuable features. The chief point of interest, however, in the diagnosis of interstitial keratitis is its association with other symptoms of syphilis, upon which, for the general practitioner at least, the diagnosis will usually depend. There is such unequivocal clinical evidence in this direction that it is safe to say, as of the question of syphilitic teeth, that the burden of disproof rests with the doubters, and we may venture the assertion that interstitial, diffuse, or parenchymatous keratitis is a symptom of inherited syphilis, and that the unmistakable presence of the former disease is sufficient proof of the existence of the latter.

Syphilis of the Nerve-centres and Nerves.—Until a comparatively recent period our only guide to the course of the nerve diseases of inherited syphilis was to be found in analogy. We knew, for instance, that in acquired syphilis three forms of cerebral disease could be recognized in a general way: one characterized by a sudden attack of paralysis, in which the lesion was usually thrombosis from specific endarteritis; one in which the symptoms of brain-tumor were present, and in which gummata were the cause of the difficulty; and one in which pain, headache, and various functional or convulsive disturbances—chorea, epilepsy, paralysis of single nerves, etc.—were the customary phenomena, and in which periosteal, meningeal, or neuroglial thickenings constituted the pathological basis. The last two are often intermingled both symptomatically and histologically.

In spite of certain striking differences—more apparent than real, however—between inherited and acquired syphilis as regards cause, duration of stages, etc., the essential pathological changes are the same. When syphilis in its later periods attacks the brain or spinal cord or nerve-trunks or vessels of a fœtus, it proceeds just as in the adult, the same characteristic accumulation of cells taking place and setting up an arteritis or a meningitis, thickening the sheaths of nerves, or constituting a pericranial node or a gumma, according to their number and their situation. We find, thus, that in these patients meningitis, growths, and arterial disease constitute the three clinical divisions of the disease which have thus far been distinctly differentiated, and the reported cases, with or without autopsy, fall naturally into these classes.

Syphilis of the Spleen.—Disease of this organ in inherited syphilis is especially important from two points of view. It is a valuable aid to diagnosis, and by the size of the organ and the degree of persistence of the swelling gives an approximate indication of the severity of the case. Enlargement of the liver, although it ought to be noted because it is often present in hereditary syphilis, has but little value as a confirmatory symptom: first, because the liver is disproportionately large in infancy, and it is difficult to state the limit of what is actually normal; and, secondly, because other causes besides congenital syphilis lead to its enlargement. With regard to enlargement of the spleen the case is different. Gee's observation, that in the early stage of infantile syphilis some

enlargement of the spleen occurs in a large number of cases, has been abundantly confirmed. The importance of this sign is greatest when noted early, as, for example, when the child is from two to three months old, for at that period the enlargement of the spleen due to rickets can hardly come into question. The condition of the spleen during this period of enlargement seems to be simply that of hyperemia, or at the most of hyperplasia.

The *cause* seems to be in all probability the well-known effect of syphilis on the glandular system in general and on the lymphatic system in particular, to which the spleen is now usually assigned. The analogy between this slow, persistent, painless enlargement preceding the cutaneous symptoms, unaccompanied by inflammatory symptoms, unattended by any breaking down of tissue, subsiding slowly but evenly under specific treatment, and the behavior of the buboes of acquired syphilis, is certainly very striking.

In most cases of hereditary syphilis there are evidences of disturbance of the **gastro-intestinal tract**. Vomiting, diarrhea, colic, anorexia, and emaciation are well-known, but of course not at all characteristic, symptoms.

It has been supposed that the mucous membrane of the entire tract is probably, during the early period at least, and coincidently with the cutaneous eruption, in a condition of hyperemia and irritation comparable to that of the skin. Whether this is so, or whether it is due to associated involvement of the glandular apparatus, has not yet been determined.

Syphilis of the Larynx.—The hoarse cry of the newborn infant, so characteristic of hereditary syphilis, depends upon the presence of hyperemia, of mucous patches, or even of extensive ulceration, in the larynx. The first is probably the most common, as, if it were otherwise, cases of death from œdema glottidis or other forms of laryngeal obstruction would be oftener met with. When ulceration does exist it is generally, but not invariably, secondary to pharyngeal ulcers.

Bronchial catarrh, giving rise to cough, and sometimes to considerable embarrassment of respiration, is a not infrequent complication of laryngeal syphilis. Later troubles of the larynx in connection with inherited syphilis have not yet been studied carefully enough to warrant us in drawing any distinction between them and the usual symptoms seen in the acquired disease.

Syphilis of the testicles is found to consist of a true interstitial orchitis, very closely resembling that seen in the syphilitic testicles of adults. The disease usually occurs at from two months to three years of age; both testicles are generally involved, and are enlarged, hard, inelastic, and frequently nodulated. Mercurial treatment generally causes a marked improvement unless the inflammation has already resulted in the development of a new fibroid formation, in which case it will be likely to remain unaffected by treatment. Inunctions with diluted mercurial ointment, iodoform, etc. are useful adjuvants.

The Diagnosis and Prognosis of Inherited Syphilis.—In reviewing the general course of a case of inherited syphilis it seems evident that the differences between it and the acquired disease which have been so much dwelt upon are apparent rather than real. The primary stage is of course missing, and on any theory of the essential nature of syphilis this is readily comprehensible. Whether the chancre is the first symptom of a constitutional disease, or is the simple accumulation at the point of original inoculation of the cells affected by the syphilitic virus, it would naturally be in the first case undiscoverable, in the second non-existent.

The secondary stage, characterized in the acquired form chiefly by lymphatic engorgement and symmetrical, widely-spread, polymorphic cutaneous and mucous eruptions, and pathologically by a marked tendency to the proliferation of cer-

tain new small round nucleated cells, upon the presence of which depend all the manifestations of the disease, is in inherited syphilis strictly analogous. The lymphatic engorgement either exists in the infant as in the adult, or has its analogue in the enlargement of the spleen and of the liver, especially the former.

The tertiary stage, except in the fact that its phenomena may appear unusually early and may be commingled with those of the secondary period, does not widely differ in the hereditary form from that of the acquired disease.

In considering the question of diagnosis, therefore, we have an excellent guide in the facts that the disease conforms in most respects to the general laws of acquired syphilis, and that our knowledge of the latter affection will be a valuable aid to recognition of the former.

The chief elements of diagnosis and prognosis of inherited syphilis in its various stages may, then, be summarized as follows: A history of syphilis in either parent is important just in proportion to the shortness of the interval between the time of infection and the date of conception. If both parents were syphilitic at or before the time of conception, the probability that the disease will be transmitted, and in a severe form, is much increased. There is no sufficient evidence that inheritance from one parent results in a graver variety of the disease than when it is derived from the other.

A history of abortion or miscarriage on the part of the mother should have weight in the determination of any given case, and if such accidents have been very frequent their diagnostic importance is greatly increased.

Upon examining the product of abortion or stillbirth the most easily observable symptoms will be those of the skin. Maceration of the epidermis and its elevation into bullæ are in themselves hardly characteristic, though both of them—and especially the latter—may be regarded as suspicious. If the cutaneous lesions are, however, distinctly papular or pustular or ulcerative, or if the bullæ have all the characteristics of syphilitic pemphigus, the diagnosis is assured.

The most distinctive symptom—one which may really be considered pathognomonic—is, however, the inflammation of the diaphyso-epiphyseal articulations, with or without their disjunction. Distinct enlargement of the spleen or of the liver and arachnitis with hydrocephalus are valuable diagnostic points, and the presence of gummata, which are not very infrequent, would of course be conclusive.

At birth the syphilitic child may be small, stunted, emaciated, weazened, senile in appearance: this would properly give rise to suspicion, but might be associated with any disorder of nutrition on the part of either child or mother. It may also disclose cutaneous or mucous eruptions evidently specific in character. In any event, marked symptoms at birth render the prognosis highly unfavorable.

It is quite common, however, for the subject of hereditary syphilis to give no evidence of the disease at birth, but even to appear healthy and well nourished. In such cases the first symptoms of the disease appear, on an average, in from six weeks to two or three months, and consist principally of coryza, snuffles, hoarseness of voice, and syphilodermata.

Mucous patches on the tongue, cheeks, tonsils, and pharynx are common, often extending to the larynx, increasing the hoarseness, and to the nasal cavities, aggravating the snuffles. Both of these occurrences, by interfering with the respiration of the child and rendering its nursing interrupted and insufficient, greatly add to the gravity of the case. Enlargement of the spleen

(common), enlargement of the liver (less so), and iritis (rare) may be mentioned among the phenomena of this stage often associated with the skin eruptions.

About the time of the subsidence of the rash there may be developed the specific inflammation at the junction of epiphyses and diaphyses which produces a swelling of the long bones near their ends. The child will be noticed to cry a little when, for example, the wrist or elbow on one side is washed, and not to use these joints as much as the corresponding ones on the other side. The parts are slightly tender, and as yet there is but little swelling. Later, the droop and disuse of the affected limb become more noticeable and simulate infantile paralysis. There is, however, no wasting, no alteration of reaction by faradism, no real loss of power, so that the term pseudo-paralysis is an appropriate one. In a week or two similar symptoms will occur in the bone on the opposite side, and finally the ends of all the long bones will be affected; ordinarily the elbows, wrists, knees, and shoulders are the joints involved. Suppuration is rare, disjunction of the epiphysis from the diaphysis common. Recovery is apt to take place spontaneously within a month. The associated changes are chiefly endosteal at the junction of the shaft with the epiphysis, but there is also a little periostitis or perichondritis, which is the principal cause of the external swelling. Moderate deformity may ensue.

Similar changes occurring in the cranial bones give rise to what has been called the natiform skull. During the first year it is very common for syphilitic children to develop a number of lenticular swellings on the cranium, which appear symmetrically around the anterior fontanel, but at a little distance from it—*i. e.* one on each frontal and one on each parietal bone. They are said to be “bossed.” They are originally circumscribed, and in a child nine or ten months old often measure from three-quarters of an inch to an inch in diameter. They are at first circular, afterward more irregular, and finally tend to organize, becoming diffused and massive and causing a permanent thickening of the skull.

The symptoms which have been described are the prominent ones occurring during the first six, eight, or twelve months of life. If they do not manifest themselves before the eighth month, it is highly probable, even in a case with a syphilitic parental history, either that the child will escape altogether or that the secondary stage has been very slight and altogether intra-uterine and unattended with noticeable phenomena. If during this first year the child's cachexia is marked, if there are any intercurrent diseases, if the symptoms show themselves early, if the nasal or laryngeal affection is severe, if the eruptions are markedly bullar or pustular or ulcerative, if the enlargement of the spleen is great or the osseous lesions are precocious or grave, and if, especially, there is any intermingling of tertiary symptoms, gummata, nodes, etc., the prognosis will be unfavorable.

From adolescence through adult life the diagnosis of inherited syphilis will depend on the following points: First, of course, the history of parental or of infantile syphilis, or of both. Then a group of physical and physiognomical peculiarities, which are not definitely characteristic, and are of little value when taken separately, but of considerable importance when all or a majority are present in any given case. These are low stature or puny development proportionate to the severity of the intra-uterine and infantile symptoms; a pasty, leaden, or earthy complexion, a relic of previous syphilodermata, probably also a result of malnutrition; a prominent forehead, bulging in the middle line at and within the frontal eminence, and due either to thickening of the skull or to a previous arachnitis and hydrocephalus before the ossification of the fontanels; a flat, sunken bridge of the nose, due to the coryza of infancy ex-

tending to the periosteum of the delicate nasal bones, and either interfering with their nutrition or partially destroying them; dryness and thinness of the hair, with brittleness and splitting of the nails; synechiæ and dulness of the iris (rare); ulcerations of the hard palate; and periosteal thickenings or enlargements of the shafts of the long bones near the ends, or slight angular deformity, the result of the osteochondritis of infancy.

A much more valuable group of symptoms, however, are the following, which are mentioned in the order of their importance, any one of the first three being almost or quite conclusive:

Dwarfed permanent median upper incisors, broader at the top than at the cutting edge, which is crescentically notched, separated by an undue interval, and converging toward each other.

Evidence of past or present keratitis—a dusky and thin sclerotic in the ciliary region and slight clouds here and there in the corneal substance, there being no scars on its surface; or of disseminated choroiditis; patches of absorption, especially around the periphery.

A radiating series of narrow cicatricial scars extending across the mucous membrane of the lips, or a network of linear cicatrices on the upper lip and around the nostrils, as well as at the corners of the mouth and on the lower lip.

Periosteal nodes on one or many of the long bones; sudden, symmetrical, and complete deafness, without otorrhea and unattended by pain or other subjective symptoms.

Late or tardy hereditary syphilis is rarely dangerous to life. The prognosis is almost unvaryingly favorable unless some grave visceral complication, such as interstitial pneumonia, gummata of the brain, liver, or kidney, or meningeal and periosteal inflammation within the cranium, should occur.

Treatment.—The prophylactic treatment, or that directed to the health and sexual relations of the parents previous to conception, has already been sufficiently considered. That of the mother during pregnancy, after having conceived from a syphilitic husband, or having had antecedent syphilis, or having contracted it by direct contagion subsequent to impregnation, is simply that of acquired syphilis in either adult or child. Mercury in its full physiological dose is the drug indicated. It may not be amiss to combine with it iodide of potassium in moderate doses, but the practice of employing the latter to the exclusion of the former is both theoretically and clinically unsound. Care should especially be taken to give it in such a manner, either by inunction or vaporization or so guarded with opium, that it shall not produce any irritating effect on the intestinal canal, the sympathy between which and the uterus may, in the event of a strong purgative action being set up, lead to an abortion.

As we have seen that the pathology, the stages, and the general course of hereditary syphilis are all closely related to or identical with the same phenomena in the acquired disease, and so know that they both depend upon the same ultimate cause, it follows that the same principle should govern us in the treatment of the one as in that of the other.

We know from clinical experience that mercury exercises an almost controlling influence over the secondary manifestations of acquired syphilis. We know also that iodide of potassium, probably by virtue of its powerful stimulating influence on the lymphatic system, has an equal power over the tertiary growths. In hereditary syphilis, however, there are two elements which should modify the treatment somewhat, and must be taken into consideration. These are—1st. The existence of a more or less profound cachexia influencing all the nutritive and formative processes, and in itself, entirely apart from any definite specific involvement of vital organs, threatening life. 2d. The not infrequent

occurrence during the secondary period of symptoms—notably gummata—belonging to the tertiary stage.

The first indication is met by making the treatment from first to last not only antisyphilitic, but also supporting or even stimulating; and with this object in view especial attention should be paid to nutrition. It may be stated, axiomatically, that for every reason, whenever it is within the bounds of possibility, the nurse of a syphilitic child should be its mother. To her it is harmless; to every other woman, not already syphilized, it is in the highest degree dangerous. If neither mother nor wet-nurse can be had to suckle the child, it must be fed by cow's, goat's, or ass's milk or by artificial alimentation; but its prospect of life will be immeasurably reduced. In addition to careful feeding, a little tonic treatment should be employed from the first, in conjunction with the specific remedies, iodide of iron, cod-liver oil, and preparations of the phosphates being the most useful drugs.

The existence of the second condition which exercises a modifying influence upon treatment—the early appearance of tertiary symptoms—is probably due, in many cases at least, to an overwhelming of the lymphatic system by the new cell-growth. This leads us to combine with the mercury from the beginning, at least in all cases where bony or periosteal involvement, suppuration, or the existence of gummata point to this condition, small doses of iodide of potassium or of some other soluble and easily-decomposed iodine salt.

The principle of treatment being recognized, the routine procedure may be thus described: Give mercury as soon as the diagnosis of syphilis is assured—preferably by inunction. Sir Benjamin Brodie's opinion, expressed many years ago, still represents that of the profession: "I have tried different ways of treating such cases. I have given the child gray powder internally and given mercury to the wet-nurse. But mercury exhibited to the child by the mouth generally gripes and purges, seldom doing any good, and given to the wet-nurse it does not answer very well, and certainly is a very cruel practice. The mode in which I have treated cases for some years past is this: I have spread mercurial ointment, made in the proportion of a dram to an ounce, over a flannel roller and bound it around the child once a day. The child kicks about, and, the cuticle being thin, the mercury is absorbed. It does not either gripe or purge, nor does it make the gums sore, but it cures the disease. I have adopted this practice in a great many cases with signal success. Very few children recover to whom mercury is given internally, but I have not seen a case where this method of treatment has failed."

When, for any reason, as irritation of the skin, this cannot be employed, probably the best form of giving mercury by the mouth is in the following formula:

R̄. Hydrarg. cum creta, gr. j-vj;
Sacch. alb., gr. xij.

M. et div. in chart. No. xij.

Sig. One powder three times a day, to be taken soon after nursing.

Iodide of potassium may be given separately in a syrupy solution in doses of a half-grain to a grain, or, if there are any marked tertiary symptoms, even in much larger doses, three or four times daily. The treatment of course should be continued long after the disappearance of syphilitic symptoms, and it would probably be well to continue the mixed treatment intermittently until after puberty.

The cases of visceral syphilis in very young children are generally fatal. Those that recover do so in response to the active use of the above remedies.

Later, the prognosis is more favorable, the treatment the same. Of course moist eruptions should be dusted with some astringent or absorbent powder; mucous patches should be cauterized or stimulated; and great attention should be paid to avoidance of sources of cutaneous irritation, by frequent changing of diapers, etc., but the general methods are the same as in the adult.

CHAPTER XIX.

TUMORS.

A TUMOR is a new growth or neoplasm which produces a localized enlargement of a part or an organ, has no tendency to spontaneous cure, has no useful function, in most cases tends to grow during the whole of the individual's life, its development and growth, except in rare instances, being uninfluenced by drugs or by the greater or less general vigor of the individual. The exceptions to which the above definition does not apply are—first, such new growths as tubercle, lupus, etc.; second, certain epitheliomata and the withering scirrhus of the breast, which do not produce enlargement; and third, cysts not the result of new growth. Lymphadenoma or lympho-sarcoma, a malignant disease of the lymphatic glands, in a few instances temporarily, or more rarely permanently, seems to have undergone cure from the use of arsenite of sodium given internally in increasing doses.

All tumors *originate from the pre-existing tissues* (except when of metastatic origin), and are composed of tissue-elements resembling those of these tissues either in their fully-developed or in their embryonic state. When limited to the tissue in which it starts, the tumor merely displaces the tissues, and is, almost without exception, constituted of fully-developed cells similar to the tissue from which it started, as fat, fibrous, or muscular tissue: to this class of tumors, which are generally benign, the term *homologous* has been applied. When the new-growth no longer remains confined to the tissue in which it starts, but infiltrates the surrounding tissues, its component elements tending to be more embryonic in their type, it is usually malignant; such growths have been termed *heterologous*. Nearly all secondary tumors—*i. e.* those forming in parts distant from the primary growth, as in the lymphatics or the viscera—are therefore heterologous. Both innocent and malignant growths may be multiple. Multiple malignant growths are usually the result of lymphatic or vascular embolism, but cases are not uncommon where more than one primary focus has been observed; thus two or three portions of the lip or of the tongue may be simultaneously attacked.

Tumors Originate from Many Causes.—Some, as *nævi*, are congenital, or the tendency to their development in later life is inherited. Of the causes initiating those occurring in later life, the following are regarded as most effective and unquestioned. While inflammatory new formations cannot be regarded as tumors, there is little doubt that inflammation—especially that following a contusion—stands in frequent causative relation to many new growths, notably the sarcomata. Anything which acts chemically or mechanically so as to maintain a constant but slight degree of undue vascularity of a part, such as the irritation of soot (scrotal cancer), the hot, rough stem of a clay pipe (labial epithelioma), a jagged tooth (carcinoma linguæ), favors the development of a malignant growth. Abnormal conditions of parts where the epithelial elements are in excess, as certain benign growths, such as warts (cutaneous papillomata), pigmented moles, and leucoma of the tongue (a

chronic inflammatory affection involving the surface of that organ), predispose to the formation of malignant growths. Age and sex predispose to tumor-formation. Thus carcinoma is a rarity under thirty years of age; the mammary gland of the female is infinitely more liable to carcinoma than that of the male, owing to their differing functional activity; while, on the other hand, the œsophagus, lip, and tongue in the male seem to be more liable to be attacked by malignant disease than the same organs in the female. The depressing emotions long continued, such as sorrow or anxiety, generally considered as predisposing causes, can act only, as does age, by lowering the vitality of the tissues, inducing as it were premature senescence: their action is therefore doubtful.

Since malignant growths present some slight apparent resemblances to certain phenomena of the infectious diseases, observers have of late years sought to ascribe their origin to bacteria. Still later, microscopic appearances simulating those presented by certain parasitic protozoa have led enthusiastic observers to the belief that the spheroidal or irregular bodies found in and between the epithelial cells are in reality developmental forms of certain sporozoa, and that their presence is not accidental, but causal. The arguments in support of this view rest upon the morphological resemblances of these bodies to psorospermia and to the corpuscles of mollusum contagiosum. The diversity in size, form, and staining qualities of the supposed parasites, the lack of evidence that these bodies are either growing or developing, and the failure of all culture methods, have caused most authorities to believe that the alleged sporozoa of carcinoma are really degeneration-products of the epithelial cells. The possibility that carcinoma may yet prove to be of parasitic origin is not denied, but certainly no positive evidence in support of this view has been adduced.

Growth.—This is dependent upon its structure primarily, and to a less degree upon the part in which the tumor starts. *Ceteris paribus*, the more embryonal the structure, the more rapid the increase and the more malignant the tumor, but tumors of similar structure pursue widely differing courses according to the organ in which they originate. This is partly due to their lymphatic and vascular connections, partly to the importance to life of the part involved or of neighboring parts which may become diseased by contiguity, or mechanically rendered partially or wholly useless; thus a small carcinoma of the pylorus will terminate life by starvation; a tumor of the larynx will early endanger life by suffocation.

Clinically, tumors are divided into the *benign* and the *malignant*. A **benign** tumor is usually composed of tissues resembling those in which it originates, and is circumscribed, because usually encapsulated, whence its mobility among the circumjacent tissues. Its vascular supply is small; hence generally it grows slowly. It is painless; it never infiltrates surrounding tissues, but displaces them; it does not recur when thoroughly removed, does not give rise to enlargement of the lymphatic glands intervening between it and the venous circulation, and consequently does not affect distant parts. A **malignant** tumor usually consists of tissues widely different from those in which it originates; its growth is rapid, and therefore often painful; it infiltrates all the surrounding tissues, however resistant, even bone, because it is almost never encapsulated; it thus early becomes immovable; the superjacent skin is apt to become adherent, especially when the breast is involved; sooner or later it usually infects the group of lymphatic glands intervening between it and the venous circulation, and from these new centres or directly through the veins gives rise to secondary deposits in the internal organs.

Diagnosis.—In general terms this must depend upon the history, age, sex, situation, rate of growth, fixity to the surrounding parts and overlying skin, or the reverse, lymphatic or visceral involvement, and the physical characters of the growth.

The *liability of tumors to degenerations* resulting from disease or injury—since morbid growths are no more exempt from such influences than normal tissues—should be clearly recognized and constantly kept in mind. Thus the vascular supply determines the occurrence of ulcerative inflammation in both benign and malignant growths. For instance, an ordinary sessile fatty tumor (lipoma) is no more liable to be attacked by ulceration than any other portion of the normal fatty tissue of the body, but when such tumors become pendulous, with narrow pedicles, the blood-supply is often interfered with—especially the venous return—and ulceration is prone to occur from trivial causes. Again, epithelial carcinomata are chiefly formed of masses of cells the majority of which are distant from any direct blood-supply; thus they readily undergo fatty degeneration and break down early; the overlying skin inflames, gives way, and ulceration is initiated. This process is often so active that the major part of the growth ulcerates or sloughs away, while at the periphery the disease extends into the adjacent tissues. Very rarely, from injury, gangrene of the whole growth ensues, resulting in its total destruction and the cure of the disease. One most important class of malignant neoplasms—viz. the sarcomata—are liable to such developmental transformations into structures resembling normal tissues, as to give rise to errors both in diagnosis and in prognosis. It must, then, never be forgotten that any of the structures normally developed from connective tissue may form either the bulk of some of the most malignant growths or isolated portions of them: thus cartilage, bone, or fibrous tissue may form the mass of a malignant growth; but these changes into tissues of a permanent type in no way modify the malignancy of the remaining tissues of the embryonal type. Such benign growths as fibromata may undergo calcification; cartilaginous tumors may soften (undergo mucoid change).

Treatment.—The only effectual treatment is removal or destruction of the growth. Benign growths should be removed if much inconvenience or deformity is present, or if disturbance of health or danger to life—present or prospective—is undoubted. It is needless to say that all malignant growths should be promptly removed, including, when possible, the whole of the organ attacked and the neighboring lymphatics and glands, as the entire breast with the axillary contents in cancer of that organ; the whole tibia by amputation in sarcoma of that bone. Special therapeutic indications will be considered when treating of each particular class of growths.

CLASSIFICATION OF TUMORS.—Tumors are best classed according to their supposed origin and their histological structure; thus—

I. *Mesoblastic or Connective-Tissue Tumors.*

A. Those conforming to the types of fully-formed connective tissues:

1. Fibrous Tumors (Fibroma, plural Fibromata);
2. Fatty Tumors (Lipomata);
3. Cartilaginous Tumors (Chondromata);
4. Osseous Tumors (Osteomata);
5. Mucous Tumors (Myxomata).

B. Those conforming to the types of the higher connective tissues:

1. Muscular Tumors (Myomata);
2. Vascular or Erectile Tumors (Angeliomata);
3. Lymphatic (vessel) Tumors (Lymphangiomata);
4. Nerve Tumors (Neuromata).

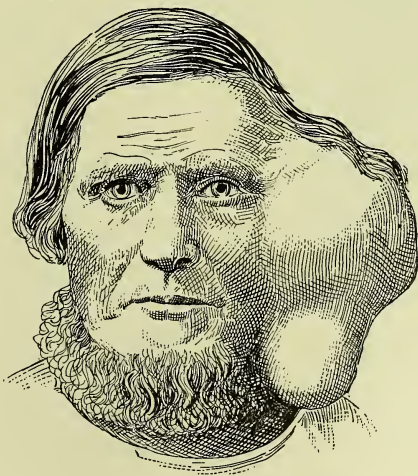
- C. Those conforming to the type of embryonic connective tissue :
 - 1. Round-celled Sarcomata ;
 - 2. Spindle-celled Sarcomata ;
 - 3. Myeloid Sarcomata.
- D. Tumors intermediate between the sarcomata and the carcinomata :
The Endotheliomata.
- II. *Epiblastic and Hypoblastic Tumors*—i. e. those conforming to the type of *Epithelial Tissues* :
 - A. Warty or Villous Tumors (Papillomata).
 - B. Glandular Tumors (Adenomata).
 - C. The Acinous or Spheroidal-celled Carcinomata :
 - 1. Hard Spheroidal-celled (Scirrhus, or Chronic Carcinomata) ;
 - 2. Soft Spheroidal-celled (Encephaloid or Acute Carcinomata) ;
 - 3. Colloid Carcinomata.
 - D. Epithelial carcinomata :
 - 1. Squamous-celled Epitheliomata ;
 - 2. Cylindrical- or Columnar-celled Epitheliomata.
- III. *Tumors composed of Epiblastic, Hypoblastic, and Mesoblastic Elements* :
Teratomata, tumors containing bone, hair, teeth, etc., situated in the ovaries or testicles.

I. MESOBLASTIC OR CONNECTIVE-TISSUE TUMORS.

A. Tumors conforming to the types of fully-formed connective tissues :

1. **FIBROUS TUMORS, OR FIBROMATA** (Fig. 25).—Consisting of fibrous tissue, they may be as dense and firm as a tendon or as soft as the subcutaneous areolar tissue. They commonly possess a distinct capsule ; when completely removed they neither recur locally nor become generalized, and consequently are absolutely innocent tumors. They rarely consist solely of pure white fibrous tissue, but the firmer varieties are composed of a dense mass of interlacing bundles of this tissue, intermingled with a few yellow elastic fibers and connective-tissue corpuscles. The bundles may form concentric circles around the blood-vessels in some fibromata, but usually they present no definite arrangement. On section they are smooth, glistening, firm, and of a grayish-white color. Usually the blood-supply is scanty, the vessels being small and thin-walled, but some naso-pharyngeal polypi are excessively vascular, being traversed by large cavernous blood-spaces. The softer varieties consist of a more or less loose, succulent, fibrous tissue permeated with numerous large blood-vessels, and according to the proportions of the different forms of fibrous tissue which enter into their composition they will appear more or less yellowish, glistening, semi-transparent, or gelatin-

FIG. 25.



Fibro-cystic Tumor of Parotid Region (original).

ous; a serous fluid can be expressed from their cut surfaces. When superficial they often become pedunculated.

Fibrous tumors are prone to undergo certain secondary degenerative changes—viz. calcification, mucoid change, and ulceration.

Seats of Predilection.—Fibromata may occur wherever fibrous tissue is found in any of its forms, but the commonest seats are the periosteum, especially that of the jaws, for the harder forms, when the tumor is called a fibrous epulis; in the uterus; in the neurilemma of nerves—then miscalled neuroma (false neuroma); in the subcutaneous tissue on terminal nerve-filaments, termed painful subcutaneous tubercles; in the rectum and naso-pharynx, forming fibrous polypi. Hard fibromata are also found in the testis or may spring from the sheaths of tendons. The softer forms originate chiefly from the intermuscular septa or the subcutaneous and submucous tissues, and are oftenest found in the scrotum, labia majora, or scalp. The soft fibroma was formerly called fibro-cellular: the ordinary nasal polypus is a typical example of this variety. Fibromata attack adults chiefly, but have been observed at all ages; they are usually single, but may be multiple when springing from the nerves (false neuromata), the skin (*mollusum fibrosum*), and the uterus. Pure fibromata and fibro-lipomata sometimes form large renal tumors.

Diagnosis.—In general terms, fibromata are ovoidal, hard, nodular, or bosselated, of uniform consistence, of slow growth, painless—except when involving nerves—movable, those in the breast and subcutaneous tissues being unattached to the skin or circumjacent tissues. In these situations, or when arising from the jaws or other bones, in their earlier stages it is difficult to distinguish them from the harder sarcomata, the latter being often encapsulated. The slow growth, the regular contour, and the non-involvement of the overlying tissues in the case of fibrous growths are the chief points of distinction. Cartilaginous and bony tumors present the same characteristics, but are much harder and more nodular. The softer fibromata are smooth, globular, elastic, soft, and painless.

Treatment.—When possible, they should be completely removed, either by enucleation with their capsules, as in most of those occurring in the breast, the interior of the jaw, etc., or sometimes by a dissection, which may be tedious. Recurrence never takes place except where a sarcoma—portions of whose mass in certain instances consist largely of fibrous tissue—has been mistaken for the benign growth.

2. **FATTY TUMORS, OR LIPOMATA**, consist of adipose tissue identical with normal fat. They are innocent, grow slowly, may reach a large size, are usually single, but occasionally multiple, are almost never painful, occur chiefly during adult life, and do not recur after removal. Composed of masses of fat-vesicles bound together by delicate connective tissue in which the blood-vessels ramify, they are usually surrounded by a thin capsule which is attached by fibrous septa to the skin. Fatty tumors may undergo such secondary changes as calcification, mucoid softening, inflammation from pressure, and, as a result of this in some rare instances, ulceration.

Seats of Predilection.—On the shoulders, back, nates—possibly from the pressure of the suspenders, from sitting, etc.

Diagnosis.—A fatty tumor forms a circumscribed, usually painless, lobulated, soft, pseudo-fluctuant, inelastic, flattened growth—if subcutaneous, causing dimpling of the skin when this is pinched up, due to the passage of the fibrous septa from the skin to the capsule. It is best distinguished from chronic abscess—with which it may be confounded—by its dimpling and by



Enormous chondroma of ilium.

the slipping away of the edge of the tumor from beneath the finger when pressed upon: possibly the grooved needle may be requisite. Certain variations should be noted. Thus there is a diffuse form, producing symmetrical swellings at the back of the neck, or beneath the chin, forming so-called "double neck" and "double chin." Again, the presence of more fibrous tissue than usual may render lipomata unusually firm. They may be deep-seated, springing from the intermuscular septa or even from the surface of a bone. Moreover, they occasionally become pedunculated. Lastly, some of the most typical cases of "painful subcutaneous tubercle" are composed of fat. The average case can be readily diagnosed from a cyst, a chronic abscess, or a bursal enlargement by the symptoms given above, while the deeper-seated can hardly be mistaken for any other than soft fibrous or myxomatous growths—an error of no practical moment, since both should be removed.

Treatment.—For the circumscribed variety a free incision, opening the capsule, should be employed, when the tumor will usually shell out; if more adherent, some dissection with the knife may be necessary: all portions of the growth must be removed, since occasionally, although rarely, the portions left have formed the starting-point of a new tumor. Multiple growths, unless painful ones, seldom require removal. The diffused form should not usually be attacked with the knife. The prolonged internal use of liquor potassæ in 10-minim doses, t. d., has in certain instances caused their disappearance.

3. **CARTILAGINOUS TUMORS, CHONDROMATA OR ENCHONDROMATA** (Pl. VII.), are composed of some variety of cartilage, forming hard, elastic, slowly enlarging growths, often nodular or lobulated. They may consist of a single mass or of a number of small masses each enclosed in its capsule, all bound together by connective tissue and blood-vessels. They are homogeneous or coarsely granular on section, presenting a translucent, bluish-gray or pinkish-white surface, sometimes marked out into irregular lobules. Histologically, they are usually composed of hyaline- or fibro-cartilage. Where unattached to bone their fibrous capsule serves as a perichondrium, and when exposed to friction a bursal sac often forms between them and the superjacent parts. Fatty or mucoid secondary changes may render some of the nodules centrally diffuent, producing cyst-like cavities containing synovia-like fluid, thus so completely metamorphosing the tumors that they sometimes are hardly recognizable as chondromata; while, on the contrary, some become calcified or ossified. This latter change is especially apt to affect chondromata springing from the juxta-epiphyseal region of the long bones, the change progressing so far that only a thin layer of cartilage caps them, forming what are termed cancellous exostoses. Chondromata are apt to be single, but they are often multiple and symmetrical, as those attacking the phalanges. While pure cartilaginous growths are benign, sarcomata are often partly, or even chiefly, composed of cartilage, especially those found in the testicle and the parotid. Multiple chondromata of the hand, if of rapid growth, should be viewed with suspicion as possibly cartilaginous sarcomata. Occurring at any age, they are more common in the young, especially those springing from the long bones near the epiphyses. Sometimes the tendency to their formation seems to be inherited, the tumors being similarly located in both parents and children. While they often attain a large size, they grow slowly, so that unusual bulk with rapid growth would justify a strong suspicion of the intermixture of sarcomatous elements. Mixed tumors containing cartilage have been already referred to.

Seats of Predilection.—The bones, especially on or in the phalanges of

the fingers or toes; the lower juxta-epiphyseal region of the femur; the upper ends of the tibia, fibula, and humerus, the scapula and ilium, on or in the jaws, especially the upper; the salivary glands, notably the parotid; the testicle; in or around joints attacked by rheumatoid arthritis; and the subcutaneous tissues.

Diagnosis.—This must depend on the hardness yet elasticity of the tumor, its nodular circumscribed outlines, and its slow continuous growth; later, on the development of softened spots indicative of cystic degeneration, and on the location of the tumor, as upon a young bone near an epiphysis. A *cartilaginous sarcoma*—the growth with which chondromata are most likely to be confounded—presents less definite outlines—*i. e.* infiltrates somewhat, is apt to be of unequal consistence from the outset, and grows with much greater rapidity.

Treatment.—Complete removal of a pure chondroma will secure future immunity, and should always be adopted when possible. Mixed chondromata containing sarcomatous elements commonly recur. In the parotid gland and subcutaneous tissues they can usually be enucleated with their capsules, and sometimes this can be done when the phalanges are involved, but more often in the latter event and when the testicle is attacked the whole part or organ must be sacrificed: usually those springing from the surfaces of the larger bones can be removed without sacrificing the bone, with but small chance of their recurrence.

4. **OSSEOUS TUMORS, OR OSTEOMATA**, are formed of true bone, and are generally composed almost solely of either cancellous or compact bone. The cancellous have been just described as resulting from the ossification of chondromatous growths springing from the juxta-epiphyseal portions of such long bones as the tibia, femur, humerus, fibula, etc., where they form exostoses. The ungual surface of the distal phalanx of the great toe is often the site of such a tumor, producing a subungual growth. The compact osseous tumors rarely grow from any other bones than those of the cranium. Certain exostoses, called from their hardness “ivory exostoses,” are said to differ from other bony growths by the absence of Haversian canals, and are composed of “layers of bone lamellæ laid concentrically over a central point or pedicle.” They rarely attain a greater size than that of a small walnut, are so dense that they can hardly be cut by any instrument, and it is difficult by the exercise of great force to fracture their pedicles, even when comparatively slender. The ivory exostosis springs from the exterior of one of the cranial bones, while the more ordinary forms of compact osteomata originate in the cranial or nasal sinuses, grow slowly, and thrust aside or cause absorption of adjacent structures, thus producing marked deformities. Although usually single, osseous tumors in some patients may be multiple, being found by the score, in such cases commonly commencing at a very early age, being then hereditary and often symmetrical.

Seats of Predilection.—These have been mentioned above in describing these growths.

Diagnosis.—This is usually easy, depending on the evident connection of the tumor with bone or cartilage, for tumors growing apart from these structures in the connective tissue are probably tumors of some other class which have undergone osseous change, or are structures, such as tendons, muscles, etc., which have undergone calcification or ossification. The pedunculated form when the osteoma occurs as an exostosis, the dense, hard, irregularly nodulated surface when the tumor is non-pedunculated, and its slow growth, serve as distinguishing points. The more rapid growth and unequal consistence of the calcifying or ossifying sarcomata serve to distinguish this variety of malignant growth from the benign osseous tumors.

Treatment.—Although operation alone can remove these growths, not every one should be meddled with, but only those should be attacked which are steadily growing and are painful or produce great deformity or loss of function, and the proposed operation on which will not unduly risk the life of the patient. Thus, most of the exostoses of the flat and long bones and certain osteomata of the upper and lower jaws should be removed, for valid reasons, such as those just given. Those of the facial and cranial bones, which are ill defined and often extend so deeply as to involve the base of the skull, should not be touched. It was formerly taught that it was inadvisable to attempt the removal of non-pedunculated, sessile exostoses of the long bones, which are usually covered by thick masses of muscle, because of the risk of profuse and deep-seated suppuration; but with modern methods of operating such complications ought to be avoided, so that if good reasons exist for their removal such tumors should be subjected to operation.

With the exception of the cancellous exostosis of the ungual phalanx of the great toe, a pure osteoma when removed does not return, even when some of the surface from which it has sprung is allowed to remain. An ossifying sarcoma, for which osteoma has sometimes been mistaken, will of course return. In the exceptional case mentioned the distal portion of the phalanx should be removed with the tumor to obviate any risk of recurrence.

5. **MUCOUS TUMORS, OR MYXOMATA**, resemble both to the naked eye and to the microscope the Whartonian jelly of the umbilical cord and the vitreous humor of the eye. They grow slowly, and may attain a large size, but are innocent tumors, not returning when pure and if completely removed. Sarcomata may undergo an analogous change—*i. e.* mucous softening—and of course such tumors are apt to recur. Mucoid softening also attacks fibromata, chondromata, and other connective-tissue tumors, so that many tumors called myxomata are chondromata, fibromata, or sarcomata undergoing mucoid (myxomatous) change.

Structurally, a true myxoma is soft, gelatinous, semi-translucent, encapsulated, and intersected by septa of fibrous tissue. Their cut surfaces are pinkish or yellowish-gray, and exude large quantities of glairy fluid containing much mucin. Microscopically, they are seen to be composed of numerous anastomosing stellate cells, with branching processes which form a delicate stroma in which the gelatinous basis-substance is contained: some round and spindle cells are also found. Inflammation, fatty degeneration, ulceration, and the formation of blood-cysts from rupture of capillary vessels are the secondary changes to which these tumors are liable.

Seats of Predilection.—The nasal cavities, in which they form gelatinous polypi; the mammary gland; the intermuscular spaces; the submucous and subserous tumors; more rarely the periosteum, the bone medulla, and sheaths of nerves.

Diagnosis.—Before removal their close physical resemblance to fatty and fibro-cellular tumors renders certainty impossible, since they present the same soft, elastic feel, and may even seem to fluctuate, thus simulating a chronic abscess: in such cases the hypodermatic needle would settle the diagnosis.

Treatment.—This should be removal when practicable. This is usually readily effected, the growth shelling out of its capsule; but careful dissection is required when they spring from large nerves, since these not uncommonly pass through the center of the tumor, so that sections of the nerve have been accidentally removed when excising such growths.

B. Tumors conforming to the types of the higher connective tissues :

1. **MUSCULAR TUMORS, OR MYOMATA.**—Only those of congenital origin seem to be composed of *striated* muscle-elements (*rhabdo-myoma*), but even in such tumors the bulk of the neoplasm is not usually composed of muscle-cells.

New growths made up in part of smooth, *non-striated* muscle-cells (*leiomyoma*) frequently occur in the uterus, forming such considerable portions of most fibromata of that organ as to induce many writers to term them myomata of the uterus. In like manner most enlarged prostates are composed in great part of unstriated muscle. Prostatic enlargements are more apt to be due to fibro-myomatous growths involving the whole organ or an entire lobe, although distinct pedunculated growths are not uncommonly found; while those of the uterus, often very large, consist usually of an aggregation of separate tumors. Uterine fibromata also often assume the polypoid form, from the extrusive efforts of the organ excited by the presence of the growth. Situated elsewhere, myomata rarely attain a great bulk. Wherever situated, they grow slowly and are quite innocent, although from their size or position they often cause the utmost inconvenience or even danger to life. They are firm, sometimes smooth, but more often nodular, their cut surfaces closely resembling those of a fibrous tumor, owing to the presence of varying quantities of true fibrous tissue; glandular structures form part of prostatic tumors.

Diagnosis.—As they are at the outset so situated as to be inaccessible to sight or touch, the reader is referred to the sections on Diseases of the Prostate and the Uterus. When the œsophagus, stomach, or intestines have been the parts affected, the nature of the tumors has rarely been diagnosticated.

Treatment.—When accessible, they should be removed. Not seldom this may require total hysterectomy.

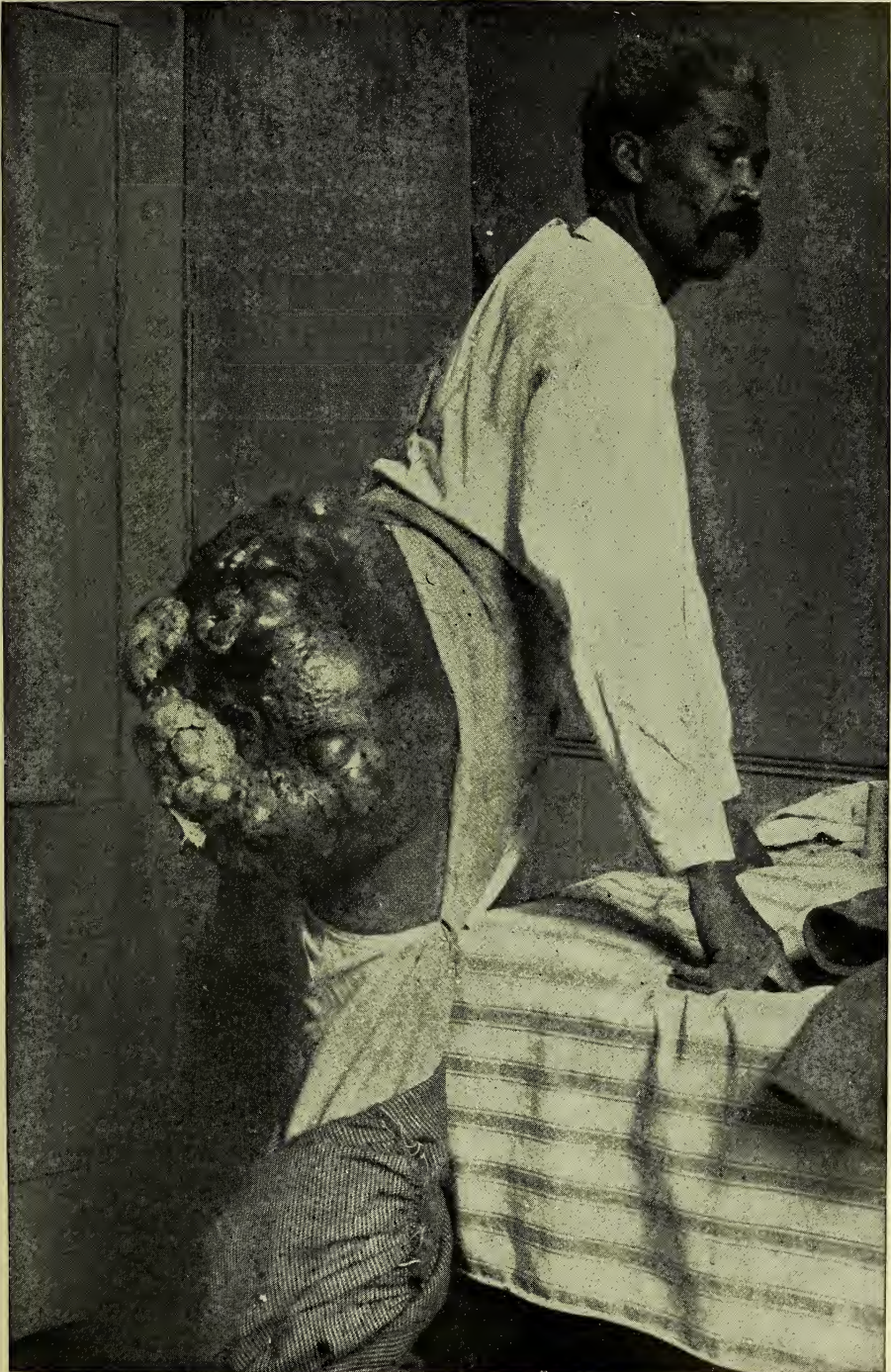
2. **VASCULAR OR ERECTILE TUMORS, OR ANGEIOMATA.**—Under this head are classed all neoplasms the chief constituents of which are blood-vessels, either arteries, veins, or capillaries, or in which the blood is contained in cavernous spaces not true vessels. Many sarcomata, and some fibromata and carcinomata, are permeated with enormous quantities of blood-vessels or channels of large caliber, but the essential element composing each tumor is not the vascular tissue, but the sarcomatous, fibrous, or carcinomatous element.

3. Both **ANGEIOMATA** and **LYMPHANGEIOMATA** will be more thoroughly discussed in the chapters on Diseases of the Blood-vessels and Lymphatics, where their treatment by excision, cauterization, ligature, or electrolysis is described.

4. **NERVE TUMORS, OR NEUROMATA.**—Such growths are of rare occurrence, whether composed of medullated or of non-medullated nerve-fibres. To avoid repetition, the student is referred to the section on Injuries and Diseases of the Nerves.

C. Tumors conforming to the type of embryonic connective tissue.

These neoplasms, called **Sarcomata** (Pl. VIII and Fig. 26), closely imitate in their structure normal embryonic or immature connective tissue, and to this class belong the fibro-nucleated, fibro-plastic, myeloid, recurrent fibroid, and many of the encephaloid cancers of the older authors. While normal embryonic connective tissue goes on to the formation of fibrous tissue, cartilage, bone, and so on, the sarcomata always retain the embryonic character at their circumference—*i. e.* their growing, advancing



Enormous sarcoma of buttock.

border, and therefore their youngest and least mature part—even in cases in which the older portions may have developed almost normally into fibrous tissue, cartilage, or bone. Therefore any rapidly-growing tumor of the connective-tissue type must have its periphery especially subjected to careful microscopic examination to determine whether sarcomatous elements exist there. While the sarcomata vary much in their structure and clinical course, they all present the following *characteristics*. The component cells contain one or more nuclei, the masses of protoplasm of which they are formed not being surrounded by any distinct cell-wall, and the cell-body is large as compared with the nucleus. The cells are “in constant relation with the stroma”—*i. e.* the intercellular cement, that which corresponds to stroma, surrounds each cell, varies in amount, and has no definite arrangement, no alveoli being formed as in carcinoma. The blood-vessels ramify among the cells, not, as in the carcinomata, running in the stroma, because of the absence of any such structure, and are very thin-walled. Indeed, they often

FIG. 26.



Sarcoma of the Arm.

appear to be nothing more than mere spaces bounded by the cells of the growth themselves. A consideration of these peculiarities of structure and of the distribution of the blood-supply readily explains the frequent occurrence of hemorrhage into the substance of sarcomata. The fact that dissemination takes place almost invariably by the blood-vessels, and not by the lymphatics, as is the case with carcinomata, is also explainable by the peculiar relation of the vessels and cells. Again, for the same reasons, the lungs, being the organs first reached by the blood after fragments of the growth have been swept away by the current, are the organs most often the seat of secondary deposits. The metastatic deposits are usually similar in structure to the primary growth. Since sarcomata grow by infiltrating the surrounding tissues, they are exceedingly apt to recur locally, doubtless because some infiltrated tissue has been left. Secondary lymphatic glandular involvement, except when the tonsil or testis is implicated, is the rare

exception—as is alleged, because of the absence of lymphatic vessels in most sarcomata: if the organs just mentioned are attacked, glandular involvement is the rule. Their growth is not slow and steady as in the carcinomata, but spasmodic, now fast, now slow. While carcinoma attacks old or senescent tissues, sarcoma most frequently occurs in organs or tissues which are developing, are in active function, or are at least in their prime; hence it is a disease of youth or early middle life. Another point in which it differs from carcinoma is that scraping a freshly-cut section does not yield a milky juice like that obtainable from the latter form of malignant growth. Not infrequently sarcomata result from an injury, such as a blow or a fracture.

So closely does one of the varieties of sarcoma—the round-celled—resemble ordinary granulation-tissue that they cannot be distinguished from each other microscopically. They both consist of small round cells similar to the white cells of the blood, separated from one another by a very small amount of homogeneous intercellular material permeated by delicate capillary vessels arranged in the form of loops. The sarcomata exhibit nearly every step in the development of the connective tissues, from this round-celled, immature tissue to bone. Thus, the cells become elongated and spindle-shaped, while the intercellular substance may show an attempt at fibrillation; or further developmental changes may ensue, converting the major part of the growth in some instances almost wholly into fibrous tissue, cartilage, or even bone, although, as has been already said, sarcomatous elements are always discoverable at the growing margins, while its malignancy, as shown by invasion of the surrounding tissues and dissemination throughout the internal organs, is in no way lessened. Calcification is often mistaken for true ossification, which is seldom met with except in bone sarcomata, and while it is true that bone may form part of any variety of sarcoma, yet it is most common in the spindle-celled and the mixed forms. Where the new bony spiculæ, in any tumor connected with a long bone, grow at right angles to the shaft of that bone, they will usually be found to be surrounded by some soft tissues, which upon microscopic examination will prove to be of a sarcomatous nature: this arrangement of the bony spiculæ is the exact reverse of that commonly prevailing in the structure of true osteomata, where they pursue a course parallel to the long axis of the bone and are surrounded by cartilage or periosteum.

Sarcomata may be grouped in three main classes—viz. the *round-celled*, the *spindle-celled*, and the *myeloid* or *giant-celled*.

1. The **ROUND-CELLED SARCOMATA** usually form soft, vascular, and very rapidly growing tumors, often becoming very large, and early giving rise to metastatic deposits in distant parts and in the viscera. Microscopically, they consist of round cells of varying size closely resembling leucocytes, imbedded in a small amount of granular or homogeneous intercellular basis-substance. On section they so much resemble brain-matter in consistence and vascularity that the old terms encephaloid and medullary seem not inappropriate. Many of those tumors formerly called encephaloid cancer or fungus hæmatodes were really round-celled sarcomata. A variety of round-celled sarcoma, where the cells lie within a stroma formed of delicate meshes closely resembling that of lymphatic tissue, is often described as *lympho-sarcoma*. Such tumors must be distinguished from irritative enlargements of lymph-glands and the adenoid hyperplasias of leukemia and Hodgkin's disease. It has been thought to have been palliated, or even to be curable in rare instances, by the internal use of arsenic. Mucoid softening, fatty degeneration, and ulceration are common secondary changes, together with the extravasation of blood

into their substance, resulting in the formation of cysts (sarcomatous blood-cysts).

Seats of Predilection.—They attack most frequently the periosteum, bone, lymphatic glands, subcutaneous tissue, testicle, eye, ovary, uterus, lungs, kidneys, and more rarely the skin, although they may originate wherever fibrous tissue exists.

Sub-varieties.—(a.) *The glioma.* This form grows from the connective tissue (neuroglia) of nerve-centers, and its basis-substance resembles that structure; the cells are apt to be small. It occurs in the retina and brain. (b) *The lympho-sarcoma*, growing in lymphatic glands, is composed of cells usually of large size, lying in a reticulum resembling lymphoid tissue. (c) *The psammoma* or *nest-celled sarcoma* is of rare occurrence, attacking only the pineal gland. (d) *The alveolar sarcoma* is so called because the basis-substance encloses each cell in a separate space or alveolus. (e) In the *melanotic sarcoma* both the cells and the intercellular basis-substance are pigmented. Both the alveolar and the melanotic form may be of the spindle-celled variety. The melanotic form is found as a primary growth only in parts normally containing pigment, as the skin and the choroid coat of the eye, becomes rapidly disseminated—the secondary growths being usually also pigmented—is probably the most malignant of the sarcomata, and by the older writers was called *melanotic cancer* or *melanosis*. *Warts* are sometimes pigmented, and thus look like this form of sarcoma, but warts are firm, often pedunculated or lobulated, and of slow growth: in rare instances pigmented warts undergo epitheliomatous change, when their rapid growth excites the suspicion that they are pigmented sarcomata, but in the epithelial growths the glands early become implicated.

2. The SPINDLE-CELLED SARCOMATA are formed of cells varying much in size, some tumors being composed of very small oat-shaped cells, others of greatly elongated bodies with long, fine, tapering extremities. Often the cells are arranged in the form of trabeculæ, which so closely imitate fibrous bands that the tumor may be diagnosticated as a fibrous or even a muscular growth.

The sub-varieties are the *melanotic*, just mentioned, and the *small-celled* and *large-celled*. When portions of these tumors have undergone developmental changes they are sometimes called chondro-sarcoma, osteo-sarcoma, etc.

Seats of Predilection.—The skin and subcutaneous tissue, the fasciæ and intermuscular septa, the periosteum and the interior of bones, the eye, the antrum, the breast, and the testicle.

Sarcomata consisting of an admixture in varying proportions of round and spindle cells, or of cells of many different forms and sizes, are sometimes called *mixed-celled sarcomata*. To the naked eye they present the same characteristics as the round- and spindle-celled forms, and they may undergo the same developmental and degenerative changes.

Seats of Predilection.—Chiefly the bones.

3. The MYELOID OR GIANT-CELLED SARCOMATA consist chiefly of large elements formed of masses of protoplasm, containing two or more nuclei—up to twenty, or even fifty—with a varying number of round, spindle, or mixed cells. They usually spring from the interior, cancellous tissue of bones, and vary in consistence from that of jelly to almost that of muscle. A section appears smooth, shining, succulent, but presents no appearance of fibrillation, and is of a greenish or of a livid red or maroon color, varied by pink or darker red spots, due to extravasations of blood. They have been compared in color to the muscular tissue of the heart.

Seats of Predilection.—The lower jaw, the lower end of the femur, and the head of the tibia; although they may occur elsewhere.

The courses pursued by the several forms of sarcomata are partly dependent upon their structure, partly upon the organ or tissue which they attack. For example, the commonest form attacking the mamma, the spindle-celled, occurs most frequently between thirty and forty years of age, is at first encapsulated—therefore freely movable—hard and nodular, grows with great rapidity, and sooner or later, from softening or the development of cysts, is apt to present points of unequal consistence, some of the consequent bosses actually feeling fluctuant. The tumor remains for a considerable time isolable from the mammary gland proper, thrusting this to one side. The skin does not usually become adherent, even when intracystic growths fungate, after having caused ulceration; although, if the tumor is left to pursue its natural course, in time not only the skin but also the subjacent parts will be infiltrated, and death will ensue from sloughing or involvement of the lungs, liver, or other viscera; the axillary glands remain uninvolved.

Examine the other extreme as exemplified by the course pursued by a giant-celled sarcoma, usually occurring in an adult over forty years of age, and attacking the body of the lower jaw, slowly expanding the bone into a smooth tumor, involving both its inner and its outer surface, the bony walls of which are often so thin as to crackle under pressure, yet growing so slowly that years may elapse before it attains the bulk of a walnut; the growth does not become adherent to the surrounding tissues, and consequently rarely ulcerates; involvement of the lymphatic glands seldom occurs.

From the preceding remarks it will be seen how difficult the diagnosis of sarcoma often is, varying as the symptoms do with the organ attacked. Occurring at all ages, sarcoma is more apt to attack the young—*i. e.* the tissues during the developmental period. Although it is the rule for sarcomata to grow rapidly, especially the secondary growths, yet some of the primary ones develop slowly, the rate of growth and bulk attained depending largely upon the tissue attacked. Those of the eye or brain are apt to be small, while those of bone often reach a huge size. While those which attack the subcutaneous tissue, the fasciæ, and the intermuscular planes are usually surrounded with a capsule, there is none for those springing from the surfaces of bones, nor for those arising in the interior of such organs as the lymphatic glands, the tonsil, etc., which are soon entirely infiltrated by the growth.

Infiltration of the surrounding tissues, even those external to its capsule (when such exists), is a peculiarity of sarcoma: this is especially true of the small spindle-celled variety (recurrent fibroid of Paget), which occurs chiefly in the subcutaneous tissue and sometimes in the breast, recurring in the course of many years a dozen or more times, while distant parts and the lymphatic glands never become infected. Attention has already been called to the early implication of the glands in sarcomata of certain organs, as the testicle, etc. The subperiosteal sarcomata are very apt to give rise to secondary tumors in other bones, the skin, the subcutaneous tissue, and the viscera, lymphatic involvement being the rare exception. Finally, certain of the softer sarcomata by hemorrhage into their substance become completely broken down and converted into cyst-like tumors filled with blood, partly fluid, partly coagulated. These if punctured bleed profusely, the hemorrhage being often difficult to control; without a microscopical examination it may be impossible to distinguish such a growth from a true hematoma (blood-cyst).

Diagnosis.—This is often difficult, and must depend on a careful consideration of the foregoing facts, together with those now to be given. The

consistence of the tumor varies much in different parts; cysts are of frequent occurrence, especially when affecting the bones, breast, or testicle; moreover, these develop, as does the growth, with a rapidity unknown in benign cystic growths; sarcomata are more apt to ulcerate than benign tumors—this is peculiarly true of recurrent growths; the ulceration, whether the giving way of the skin be due to infiltration, as is the rule, or merely to advancing pressure, is apt to be preceded by a reddened, tender, hot skin, thus presenting such symptoms of inflammation as will embarrass the diagnosis in doubtful cases. In any given case the questions to be considered are—Is it an inflammatory trouble, or is it a malignant growth? If a malignant growth, is it sarcoma or carcinoma? The first question can probably be answered by the history, by the absence of the systemic indications of an acute suppurative inflammation, and, above all, by the marked differences of consistence exhibited by different portions of the tumor. The second query, as to the class of malignant disease to which any given growth belongs, can, with the exception of primary growths attacking the tonsil, the testicle, or the lymphatic glands themselves, be settled by the early involvement of the lymphatic glands in carcinoma and their immunity in sarcoma, and by the frequent presence of cysts, the greater mobility, the freedom of the overlying skin, the enlargement of the superficial veins, and the greater rapidity of growth in the latter disease. Retraction of the nipple in a case of tumor of the breast points to carcinoma rather than to sarcoma. The peculiar features assumed by sarcoma as it affects each organ often afford valuable information, and for this the student is referred to the appropriate sections of this work.

The **prognosis** varies with the site of the disease; thus, a myeloid (giant-celled) sarcoma of the lower jaw is not uncommonly curable by operation, while a sarcoma of the tonsil or lymphatic glands destroys life with great rapidity. As has just been pointed out, recurring small-celled sarcoma of the subcutaneous tissue may be repeatedly removed, the system remaining free; or amputation, if a limb be involved, will probably cure the disease. It also varies with the variety of the disease: the more embryonic the form the greater the malignancy. Thus the round-celled variety is by far the most malignant form, the spindle-celled less so, and the myeloid the least.

Treatment.—This depends partly on the variety, partly on the organ attacked. While it is true that a myeloid tumor of the lower jaw may after thorough enucleation never recur, it is far safer to remove at the same time as much of the surrounding tissue as can be done with safety. When the long bones are the seat of sarcoma, amputate high up—if possible, through the joint above: this is likewise good practice when sarcomata of the soft parts of the extremities recur, especially if they are of the round-celled type. If the upper jaw is attacked, the whole maxilla of that side must be removed, but the prognosis will be bad. Sarcomata of the lymph-glands or of the tonsil are so little influenced for good by operation that, except as a mere palliative, removal, as a rule, should not be attempted. Tumors of the subcutaneous tissue or inter-muscular fascia should be removed as often as they recur, or amputation may be resorted to when a limb is concerned. It has been long known that occasionally an attack of erysipelas will cure a sarcoma. Lately, the treatment of inoperable sarcomata by hypodermatic injections of the toxins of erysipelas, instead of the streptococcus itself, has been revived, especially by Coley. The toxin of the bacillus prodigiosus added to that of erysipelas increases the reaction. A few cases of apparent cure have been reported by Coley, Mynter, and others, but most other surgeons have met only with failure.

Emmerich and Scholl have recently used the serum of a sheep immu-

nized by inoculation of erysipelas toxins in the treatment of inoperable carcinoma and epithelioma with apparent success.

D. The Endotheliomata.

These, as yet, little-known tumors, occupying apparently the border-land between sarcomata and carcinomata, must be briefly considered, since it appears probable that some sarcomata of the testicle are of this nature, and, developing at least in part from the endothelium of the lymphatics, give rise to that early infection of the glands so characteristic of testicular sarcoma, and yet so contrary to the natural history of the disease as it occurs in nearly every other situation.

When arising in the pia mater, structurally and from their mode of origin many of these endotheliomata are alveolar sarcomata, while those originating in the pleura or peritoneum are carcinomatous, consisting of nests and clusters of epithelial cells presenting at their periphery a columnar appearance, these cell-masses being surrounded by a dense fibrous stroma: the cells follow very exactly "the course of the lymphatic vessels." They present themselves in the form of "multiple flattened nodular growths, white in color, and either isolated or connected by neoplastic bands, the intervening serous membrane being more or less thickened;" metastasis is common, giving rise, when the pleura, for instance, is the seat of the primary tumor, usually to secondary growths in the peribronchial fibrous tissue, the bronchial glands, and the thoracic muscles. Attacking as they do chiefly the pleura and peritoneum, nothing definite can be said concerning their diagnosis or treatment, and they have been mentioned here because of their apparent etiological relations to other malignant growths, and because, although rare, recorded cases are becoming more frequent.

A. WARTY OR VILLOUS TUMORS, OR PAPILLOMATA, closely resemble in their structure hypertrophied papillæ of the skin or mucous membrane, some of the varieties receiving other special names, as condylomata, mucous tubercles, and "benign villous tumors." They are often due to some form of irritation, as in the case of those which develop on the glans penis from the action of acrid discharges, or those on the hands from dust and dirt. Rarely attaining a large size, and attacking only the skin or the mucous membranes, they are innocent growths, although during the cancerous period of life they are apt to degenerate into epithelioma, and the villous tumor of the bladder may destroy life by the hemorrhage to which such a growth often gives rise. Structurally, they are composed of a varying amount of connective tissue surrounding one or more central blood-vessels, and are covered in by one or several layers of epithelial cells resembling those of the skin or mucous membrane from which they are developed; but the cells never transgress their connective-tissue limit—*i. e.* they do not infiltrate, as epithelioma does.

Warts or *warty growths* either occur as circumscribed growths, or more rarely form cauliflower masses, large relatively to the size of the part, such as those occurring in the larynx. The enlarged papillæ are covered by a layer or layers of horny epithelium, and their vascular supply, as a rule, is small.

Mucous tubercles and *condylomata* consist of flattened elevations composed of enlarged papillæ; their connective tissue, of rapid growth, is infiltrated with numerous small round cells, and their epithelial covering is moist and sodden. They are most commonly due to syphilis.

Villous tumors, when springing apparently from the vesical mucous membrane, where papillæ do not normally exist, originate from the subepithelial con-

nective tissue and owe their papillary form to the concentric arrangement of the connective tissue and epithelium around the blood-vessels. These can, however, best be described here. Such growths assume the branching, dendritic form of the villi of the chorion, and are very vascular, the vessels being often dilated and thus liable to give way, producing the frequent and serious hemorrhages common to this affection of the bladder. Their epithelial layer is thin, and often removed mechanically, being passed in the urine, where it can be detected by the microscope.

Seats of Predilection.—*Warts* and *warty growths* occur most frequently on the skin, especially of the hands and genitalia, and on the mucous membrane of the larynx. *Mucous tubercles* and *condylomata* are most commonly found about the anus and genitals or in the mouth and throat. The *villous growths* attack the bladder, rectum, and larynx.

Such secondary and degenerative changes as pigmentation, ulceration, and atrophy are common, while with advancing years the epithelial elements may infiltrate the connective tissue, resulting in epithelioma.

Diagnosis.—The signs and diagnosis of tumors attacking such diverse organs cannot be profitably discussed here, and can be best studied in the articles on the Skin, Bladder, Rectum, Larynx, and Syphilis.

Treatment.—As this varies with the parts involved, it can only be said, in a general way, that these growths should be removed by such means as sulphuric or nitric acid, etc., which will destroy the base from which they spring; or this base, after their excision by the knife or scissors, must be destroyed by a caustic or by the actual cautery in some form.

B. GLANDULAR TUMORS, OR ADENOMATA, are innocent growths, and originate only from pre-existing glandular tissue, which they closely imitate. As of normal gland-tissue, so of these tumors there are two types, the *acinous* and the *tubular*. The *acinous* are composed of acini lined with spheroidal epithelium, intercommunicating by duct-like channels: mammary adenomata are of this type. The acini are bound together by a varying amount of connective tissue in which the blood-vessels ramify. Pure adenomata are rare, the inter-acinous tissue usually being replaced by a considerable amount of fibrous tissue (adeno-fibroma), mucous tissue (adeno-myxoma), or sarcomatous cells (adeno-sarcoma); again, the admixture of fibrous tissue with the sarcomatous elements, or of mucous tissue similarly disposed, results in other growths (adeno-fibro-sarcoma, adeno-myxo-sarcoma); still further, from obstructive pressure the acini or ducts may become dilated, forming cysts into which proliferating growths (intracystic growths) may project: such growths receive their names from the character of the interacinous and intertubular tissue, being termed adeno-cystoma, cysto-sarcoma, etc.

The *Tubular Adenomata* consist of tubules lined with cylindrical epithelium, and therefore spring from mucous membranes the glands of which are similarly constructed, as from that of the intestines. Closely resembling carcinomata in many respects, unlike them the epithelial elements do not infiltrate the connective tissue.

Seats of Predilection.—The *acinous* occurs chiefly in the mammæ—generally in the form of adeno-fibroma—in the lip, ovary, testis, prostate, thyroid, parotid, lachrymal gland, the cutaneous and sebaceous glands: the *tubular* variety occurs in the intestine, especially the rectum. Secondary degenerations, such as mucoid softening of the stroma and fatty degeneration of the epithelium, frequently produce cystic changes by obstructive pressure on the acini or duct-like portions of these growths.

II. EPIBLASTIC AND HYPOBLASTIC TUMORS, OR THOSE CONFORMING TO THE TYPES OF EPITHELIAL TISSUES—THE CARCINOMATA.

The malignant tumors of this class are composed of cells of the epithelial type "in constant relation with one another"—*i. e.* no visible intercellular matrix is discoverable—forming nests surrounded by more or less fibrous stroma. This alveolar arrangement of the cells is due to the fact that the cells, having broken through their "connective-tissue limit," now occupy the interstices of this tissue—*i. e.* the radicles of the lymph-system—forming *intercommunicating columns of cells, which in cross-section, surrounded with their fibrous stroma, present the appearance of true alveoli*. Unlike adenomata, the cell-groups are not limited by any basement membrane, while the vessels differ from those of sarcomata by having walls of normal thickness and construction; moreover, they ramify in the *stroma*, not among the *cells* themselves. Two points should be noted—*viz.* that although the individual cells differ somewhat from one another, they retain the type of the parent epithelium, being more or less spheroidal when originating from a gland, squamous if derived from the skin, squamous or more often columnar when springing from a mucous membrane. Still further, the cells of the secondary growths usually closely resemble those of the primary tumor. The normal connective tissue of the part, which at first forms the stroma, is infiltrated with numerous cells, which later, by development into fibrous tissue, produce the denser stroma characteristic of some forms of carcinomata.

The development of this fibrous tissue, studied in connection with the disposition of the blood-vessels, explains the differing behavior of the rapidly-growing tumors and those of slower growth. In the former the vascular supply is rich and tolerably evenly distributed throughout the growth, while there is relatively little stroma, what is present probably being not much more than the normal connective tissue of the part incapable of active contraction and consequent obliteration of the blood-vessels. In the tumors of slower growth the blood-supply is more scanty originally, and is found chiefly at the periphery of the growth, having been obliterated in the more central older portions by the contraction of the large amount of newly-formed fibrous tissue. Hence the fatty degeneration of those portions, resulting in their breaking down, with loss of substance, when occupying a free surface or after giving way of the skin in more deeply situated growths: this is the so-called *ulceration of new growths*. Owing to the abundance of blood-vessels and the lack of support afforded by the scanty stroma of the rapidly-growing carcinomata, hemorrhage into their substance is not uncommon, with free bleeding from the surface when ulceration has taken place. Carcinomata possess no capsule at any stage of their development, growing by endogenous cell-division and by infiltration of the surrounding tissues, as a rule sooner or later breaking down and ulcerating. As the cells proliferate in the lymphatic spaces of the connective tissue, or, as is alleged for the breast, originate in what are said to be spaces in direct continuity with the lymphatic vessels, the nearest lymphatic glands early become involved, then those next in order, and finally the viscera. In external carcinoma the general health does not usually suffer until after ulceration, with its consequent purulent and bloody discharges, or secondary implication of one or more of the important viscera, has occurred, when what is known as "the cancerous cachexia" sets in, characterized by a peculiar sallow, earthy hue of the skin, anxious, careworn facies, and more or less marked emaciation. Death finally results from the combined effect of the

purulent and hemorrhagic discharges, from the impairment of nutrition through involvement of important viscera, and from pain, anxiety, and loss of sleep. In internal carcinoma, especially of the digestive organs, this cachexia soon sets in, inasmuch as the general nutrition of the body is disturbed very early in the disease. Possibly also the absorption and diffusion of secondary products of the carcinoma may have some influence in causing this cachexia.

Carcinomata are divisible into *two main classes*, with certain sub-classes:

(C) The acinous or spheroidal-celled:

1. The hard spheroidal-celled (scirrhus);
2. The soft spheroidal-celled (encephaloid);
3. The colloid, probably a degenerative form of one of the preceding varieties.

(D) The epithelial:

1. The squamous-celled;
2. The cylindrical- or columnar-celled.

(C) **Acinous or Spheroidal-celled Carcinoma** originates only from the epithelium of the acinous glands or from that lining the tubular glands possessing glandular epithelium. The essential difference between the two chief divisions of this class is in the relative amounts of stroma and cells, the hard form containing large amounts of fibrous tissue, while in the soft carcinomata the cells preponderate. The term **Scirrhus** has been applied indiscriminately to the harder forms of spheroidal-celled carcinomata and to the whole class.

1. **HARD SPHEROIDAL-CELLED CARCINOMA, OR SCIRRHUS**, appears as a hard, irregular, tuberous growth of moderate size; if originating in a glandular structure, it is continuous with it; at the outset freely moving with the gland, but later by infiltration losing this mobility because adherent to the skin, fascia, muscles, etc. Implication first of the nearest group of lymphatic glands, and next of the viscera, and finally ulceration of the superjacent tissues, complete the natural history of the growth. The carcinomatous ulcer is irregular in outline and depth, has hard, nodular, everted margins, while the base is indurated and irregular, sometimes more or less covered with sloughs, and but rarely presents any evidences of granulations, although in very exceptional cases these exist with slight attempts at cicatrization. The duration of life in this affection is about two years, but occasionally patients live for many years, even twenty, during much of which time ulceration may exist. Of course these remarks apply only to external tumors. Owing to the large amount of newly-formed connective tissue in the hardest forms of scirrhus, in some instances the tumor, instead of growing larger as time goes on, becomes smaller, the surrounding tissues being irregularly puckered and drawn in toward the small central shrivelled lump which forms the tumor; this is the so-called *withering* or *atrophic scirrhus*, best seen in the breast, where after it has existed for years nothing but an irregular mass resembling a cicatrix is to be found, blending into one inseparable growth what formerly was skin, mammary gland, and chest-wall. Unfortunately, the malignant tendencies of the growth are not abolished by its shrinkage, for secondary tumors develop in the viscera, destroying the patient. (See *Diseases and Injuries of the Breast*.)

On section, hard carcinomata are firm, of a white color, often traversed by fibrous septa, and creaking under the knife; the cut surface is cupped. The section is succulent, yielding on pressure or scraping a milky fluid, the so-called *cancer-juice*. Howsoever circumscribed the tumor may appear, it is one of the rarest of pathological curiosities to find it encapsulated. Islets of normal tis-

sue or fat can often be detected at the periphery of the new growth surrounded by carcinomatous tissue; indeed, no definite tumor is discoverable in certain cases, the neoplasm being disposed throughout the affected organ in the form of nodules and cord-like bands.

Seats of Predilection.—The mammary gland, the alimentary tract, especially the pyloric end of the stomach, and, in a few instances, the glands of the skin.

2. SOFT SPHEROIDAL-CELLED (MEDULLARY OR ENCEPHALOID) CARCINOMA.—Differing, as already said, from the preceding variety merely by the amount of fibrous tissue, in its typical form soft carcinoma on section closely resembles brain-tissue both in appearance and in consistence. Clinically, the chief points wherein it differs from the hard form are the greater softness of the growth—so soft as at times to simulate and be mistaken for abscess—the greater bulk attained, the short time required to reach this size, and the rapidity with which it runs its course. In form the soft carcinomata differ according to the organ attacked. Thus those of the testicle form large, bossellated masses, while mammary growths tend to form a large globular mass or one composed of an aggregation of rounded masses. When ulceration has taken place a fungating, readily-bleeding mass often forms; hence the old name of “*fungus hæmatodes*.” The secondary and degenerative change which these carcinomata undergo is softening at their central older portions, due chiefly to fatty degeneration, but partly to giving way of the blood-vessels, which often results in the formation of such large fluctuating areas that, as has been said, they have not infrequently been mistaken for abscesses. Such tumors on section show that their central portions are converted into a soft, diffuent mass, while the periphery of the growth presents the ordinary grayish-white or cream-colored, brain-like surface, blotched here and there with blood. This softening also results in cyst-like cavities of considerable size, giving to the tumor the appearance of a true cystic growth. In some carcinomata of the testicle, the mamma, and other glands true retention-cysts form.

Locally, carcinomata extend by infiltration of the circumjacent tissues; this accounts for the clinical phenomena of adhesion of the tumor to neighboring parts, its decreasing mobility as it grows, and its final absolute fixation. With occasional exceptions, as in some carcinomata attacking the eye, the antrum, or the pylorus, early secondary lymphatic involvement is the rule, the secondary growths usually resembling the parent one. Occasionally they are of the soft form, even though the primary tumor is of the hard variety, thus demonstrating the essential unity of both forms. The organs and viscera most apt to be affected by metastatic deposits are the skin, the bones, especially the vertebræ, the liver, the lungs, the kidneys, and the brain. Even when, after operation, no local recurrence takes place, the possibility of this visceral implication must never be lost sight of, especially if pains in the lower limbs are complained of, if so-called “spontaneous” fracture of a long bone occurs, preceded or not by pain or tumor, if obscure symptoms of vertebral disease or if peculiar cerebral symptoms appear. Among surgical rarities is the secondary carcinomatous involvement of the medulla of many bones without the formation of distinct tumors in any, but so reducing their strength that numerous fractures occur, either from the application of trifling force or, as it is said, “spontaneously.”

Seats of Predilection.—The testicle, liver, bladder, kidney, ovary, fundus oculi, and more rarely the breast.

3. COLLOID CARCINOMA.—This is really one of the preceding varieties



Malignant lymphoma (Hodgkin's disease).



Ulcerated epithelioma of chin and neck.

the cells of which have undergone mucoid or colloid degeneration and so distend the alveoli that these can be seen by the naked eye. The colloid material is a semi-translucent, glistening, jelly-like substance, in some parts of the growth being even diffuent: generally here and there a few spheroidal cells are found; it pursues a course similar to, but somewhat slower than, that of other carcinomata.

Seats of Predilection.—The stomach, intestine, omentum, ovary, and occasionally the mammary gland.

Diagnosis of the Carcinomata.—They are exceedingly rare before thirty years of age, and are common after forty years; early lymphatic involvement is the rule—contrary to what is true of the sarcomata. Innocent growths occur, as a rule, in younger patients, do not grow so rapidly, do not infiltrate the organ or neighboring parts—*i. e.* do not become adherent—and almost never ulcerate; and when ulceration does occur, the characteristics of the resulting ulcer differ widely from those of the ulcer attendant upon carcinoma. It is said that carcinoma never attacks the testicle in the child, but that at any age a malignant tumor of the testicle which on section contains either cartilage or bone cannot be carcinomatous, but is sarcomatous. While it is usually easy to make the diagnosis of carcinoma, yet at times this is difficult or impossible, competent surgeons having removed breasts, believing them to be carcinomatous, when the disease was simply cystic or merely a chronic abscess. There is no means of distinguishing that very rare condition, encapsulated carcinoma, from a benign tumor—*e. g.* a fibroma. Between chronic mastitis or abscess and carcinoma the association of pregnancy or lactation in most instances when the mamma is the organ involved will assist in the diagnosis, while the greater density of carcinoma and its unequal consistence in its different parts when undergoing softening will often remove all doubt. Unfortunately, the skin over a chronic abscess and that over a softening carcinoma are not so dissimilar in appearance as to preclude all chance of error, especially as the glands may be enlarged in both affections. The decided elasticity of a cyst, even if fluctuation cannot be detected, its circumscription, and its free mobility, serve to distinguish this class of tumors from carcinoma. It is far better, in any case of doubt whether the tumor is really an abscess, a cyst, or a softening carcinoma, either to explore with a hypodermatic needle or at the time of operation to make first an exploratory incision directly into the tumor.

(D) The Epithelial Carcinomata.—1. The SQUAMOUS-CELLED EPITHELIOMATA always spring either from free epithelium-clad surfaces, as the skin or mucous membranes, or from the glands of the same, since the hair and sebaceous glands in certain instances have been observed to take the initiative in the carcinomatous process. These growths appear with great frequency at the points of junction of mucous and cutaneous surfaces (Pl. IX, Fig. 1), probably because there subjected to more frequent and varied forms of mechanical and chemical irritation. Structurally, they are composed of pegs or columns of squamous cells, which infiltrate first the subjacent connective tissue, then every underlying structure, including bone, in their track. The epithelial ingrowths contain globular masses of flattened cells, the so-called "*cell-nests*" or *epidermic pearls*. The surrounding fibrous stroma is usually infiltrated with small cells. Epithelioma commences either as a wart-like growth, a flattened tubercle, or a fissure, ulceration in all these forms setting in early. In many instances this proceeds with such rapidity that the tumor-formation barely keeps pace with it, the resulting disease resem-

bling—and being often mistaken for—an ulcer, the indurated base and margins either escaping detection or being looked upon as inflammatory. The other extreme is often met with where tumor-formation is in excess, only superficial ulceration obtaining until the growth is of considerable size. Epitheliomata are not encapsulated, although upon section their margins appear sharply defined from the surrounding tissues, while the cut surface is white, dense, homogeneous, poor in juice, but if compressed laterally giving vent to milk-white, twisted, thread-like masses which have been likened to the “comedones” that can be pressed out from the sebaceous glands of the skin. The consistence varies much, but is distinctly greater than that of the surrounding tissues, and the part feels dense and inelastic. Although an epitheliomatous ulcer may resemble that resulting from any other form of carcinoma, yet sometimes it is a mere fissure with indurated margins, a relatively indolent ulcer with the same peculiarities, or has superadded numerous papillary projections, producing a warty or cauliflower-like growth. When originating from an old wart—a not unusual occurrence—ulceration is apt to be the first symptom, with subsequent induration of the base of the growth. The same remarks are applicable to many cases of epithelioma of the tongue, where an indolent ulcer may last for weeks before the characteristic induration of its base and margins can be detected. The rate of growth varies with the vascularity and looseness of texture of the tissues. Thus, when attacking the lower lip the progress is slow, lasting sometimes for a year or more before the tumor attains a size greater than that of a cherry, while relatively bulky tumors will form in a few months in carcinoma linguæ.

“Spontaneous fracture” or gradual bending of the tibia is not uncommon from the infiltration of that bone by cancerous tissue, either when an old ulcer undergoes a malignant change (Marjolin’s ulcer), or when a scar, after long-indolent ulceration, commonly starting at its center, becomes similarly diseased. In like manner complete solution of continuity of the lower jaw may result from epithelioma of the lip extending to the gums and thence to the bone. Local recurrence is common after operation when the removal has been imperfect, and death usually results from the exhaustion incident to ulceration and hemorrhage. Secondary lymphatic involvement occurs with most squamous-celled epitheliomata, but usually late in the disease, when the antrum, the interior of the larynx, or the skin of the eyelids, nose, and other parts of the face is attacked. In these latter situations, indeed, the disease being apt to be superficial and of that form called “rodent ulcer,” the glands are rarely affected. The exception in the case of the intrinsic parts of the larynx is the more striking because epithelioma of the extrinsic parts affects the glands certainly and early. Visceral involvement is rare, the liver, lungs, kidneys, bone, and skin suffering most frequently.

Seats of Predilection.—Any cutaneous or mucous surface covered with squamous epithelium. When the disease attacks the skin, the parts most commonly involved are the nose, the lower lip, the penis and scrotum, the vulva, the anus, and more rarely the hands and feet. The mucous surfaces most commonly affected are those of the tongue, palate, gums, tonsils, larynx, pharynx, and œsophagus down to the cardiac orifice of the stomach, the bladder, and os uteri.

Diagnosis.—The disease is very uncommon under thirty years of age; it is quite common after forty: it is limited in some of its forms, as epithelioma of the lower lip, almost exclusively to men, and, wherever occurring, attacks men much more frequently than women. If, then, a man of from forty to seventy years of age develops a small tumor in the lower lip which ulcerates early, giving rise to an indolent, slowly-extending sore, with indurated base and margins, no evidence of surrounding inflammation being detectable, the ulcer per-

haps presenting the peculiar warty, cauliflower surface mentioned, and especially if the submaxillary glands are enlarged, the disease may be safely considered carcinomatous. Or, again, an obstinate fissured ulcer, often scabbed over, forms in the same situation, discharging a watery matter, with induration extending in all directions for full one-fourth to one-half of an inch, involving not only the mucous and cutaneous tissues, but all the structures of the lip; perhaps in addition the patient states that the disease first appeared as a wart which had been picked off or cauterized—*i. e.* had been irritated, not destroyed. Epithelioma of the tongue may appear at an earlier age, and in from three to six months will often reach a considerable size in the rarer form, where the disease appears as a hardened, non-inflamed mass on the free border of the tongue—not uncommonly near a broken tooth—its surface eventually becoming fissured, ulcerated, and painful. Or, again, there may be merely an indolent, slowly-extending, unhealthy ulcer with indurated base and margins situated as just mentioned. Although the diagnosis between carcinoma and tubercle or syphilis of the tongue is often difficult, coexisting syphilitic lesions or old scars of the tongue, with antisyphilitic treatment, will usually settle the question, while signs of tubercle elsewhere ought to arouse grave doubt of the carcinomatous nature of the ulcer. Further diagnostic points are given in the section on Syphilis.

Warts on the hands or scrotum, or elsewhere, in elderly chimney-sweeps or in coal-tar- or paraffin-workers should be viewed with suspicion, especially if they are growing and if their bases are becoming indurated, because in such cases, sooner or later, an unhealthy ulcer, discharging foul matter, usually forms, presenting all the clinical evidences of epithelioma. It hardly needs to be said that epithelioma is evidently induced by persistent irritation, since the localities where it occurs are subjected to frequent slight traumatisms, and the occupations which give rise to it supply constant sources of mechanical and chemical irritation.

Local recurrence is common after operation as a consequence of imperfect removal of the disease, and death in these cases, as well as in those not operated upon, results from the exhaustion incident to ulceration and hemorrhage rather than to dissemination, which, as has been already pointed out, is of rare occurrence.

2. CYLINDRICAL- OR COLUMNAR-CELLED EPITHELIOMA.—This is a less common form of carcinoma than the spheroidal-celled or the squamous-celled varieties, and originates from either the cylindrical surface epithelium of a mucous membrane or that of its glands, closely imitating these structures in microscopical appearance; no “cell-nests” are found. These growths form indurated, infiltrating masses in the walls of the organs attacked, and vary much in the rapidity of their course, producing considerable stenosis of the lumen of such hollow viscera as the rectum and small intestines, which may terminate life by producing more or less intestinal obstruction; ulceration occurs early. Dissemination throughout the liver, lungs, and other organs occurs, as a rule, only after infection of the intervening lymph-glands. (See Diseases of the Intestines and Rectum.)

Seats of Predilection.—The rectum, uterus, and intestinal tract.

Diagnosis.—This is to be made by attention to certain secondary results, which will be found detailed in the sections on Diseases of the Intestines and Rectum.

Treatment of the Carcinomata.—The first question to be answered is, Can this case be treated radically, or does it admit only of palliation? If it can be treated radically, the *whole organ* should be excised, including as much

as can safely be removed of the surrounding *apparently* healthy tissues, *before lymphatic involvement has occurred*, if possible: after this involvement has taken place the primary growth must be removed with an unsparing hand, while the lymphatic glands and peri-adenoid tissues must be thoroughly cleared out. Indeed, if this last all-essential requisite cannot be secured, removal of the primary growth is indicated only for the relief of pain, or, if ulceration has set in, to get rid of a disgusting sore. For instance, in a case of mammary carcinoma, if axillary glandular involvement is present, and there is any question as to the possibility of clearing the axilla, as a preliminary to further operative interference an incision should be made into the armpit to determine whether all diseased tissue can be removed. If this cannot be done—unless the breast tumor is ulcerated, when removal may be indicated as a palliative measure—the wound should be closed and the breast allowed to remain, since its removal would add a risk with no compensating advantage. (See Diseases of the Breast.) Amputation of the limb high up, with extirpation of any diseased glands, is always indicated where epithelial carcinoma has invaded the bone from an overlying tumor, as, for instance, the tibia. Malignant disease of such parts as the penis and the tongue is properly treated by amputation of these organs, even when secondary glandular disease is beyond removal, merely as a palliative measure to secure urination in the former case and painless swallowing in the latter.

Epitheliomata of the lips, nose, and eyelids can often be successfully removed by the knife even when extensive, and the defects can be repaired by plastic operation or by Thiersch's method of skin-grafting. The more superficial forms can often be effectively handled by freezing with rhigolene spray, thoroughly curetting, the application of pyrogallic acid, and an after-dressing with an ointment of the same (grs. x @ 3j), until healthy granulations are formed, when ordinary measures will secure healing or Thiersch's skin-grafting may be used. Potassa fusa or the actual cautery may be employed as the destructive agent, and, after separation of the slough, the defect may be left to Nature's efforts or skin-grafting may be resorted to. The chances of cure vary with the part involved, but even with extensive glandular complications, where complete extirpation is possible, some carcinomata of the lip, tongue, and breast do not recur either locally or in the viscera. Carcinomata of the testicle, œsophagus, or tonsil are rarely benefited by operation, except for the palliation effected. When operation is contraindicated, opium to relieve pain, local applications of lead-water and laudanum, extract of aconite and belladonna rendered of a proper consistence by glycerin, or other similar remedies, with attention to the general health, constitute the treatment in non-ulcerated carcinomata. For ulcerated carcinomata measures to control pain, to lessen discharge or hemorrhage, and to arrest fetor are the main indications. Iodoform with morphine in proper amount dusted over the surface, cocaine in solution applied either by spray or by painting, solutions of carbolic acid, Labarraque's solution, or a solution of chloral may be used, as far as possible employing dry dressings or those which favor rapid drying of the discharges—*i. e.* lessen putrefactive changes. Esmarch's arsenical powder also serves an admirable purpose. No internal remedies of the many recommended having as yet proved of any real value, none need now be mentioned. Finally, the profession should clearly understand, and endeavor to educate the public in the belief, that *early and radical operations will cure a considerable proportion of cases*, and render life endurable in many more where a cure is impossible.

III. TUMORS COMPOSED OF EPIBLASTIC, HYPOBLASTIC, AND MESOBLASTIC ELEMENTS, and containing bone, hair, teeth, etc. (Teratomata), situated in

the ovaries and testicles. These are considered with these organs, especially with the ovaries.

CYSTS.

A cyst may be defined as a cavity bounded by a distinct envelope composed of fibrous tissue lined with endothelium, and called the cyst-wall; or it may be covered by epithelium and contain secreting structures: the cyst-contents may be either fluid or semi-fluid; intracystic growths may nearly or completely fill the cavity. A cyst may result from the increase of the normal secretion of an already-formed space or cavity by extravasation into it, or the cavity may be of new formation.

I. *Cysts formed by the Distention of Preformed Cavities or Spaces:*

- (a) Exudation cysts;
- (b) Retention cysts;
- (c) Extravasation cysts.

II. *Cysts of New Formation:*

- (a) Simple cysts;
- (b) Blood cysts.

III. *Cysts of Congenital Origin.*

IV. *Cysts due to Parasites.*

I. CYSTS FORMED BY THE DISTENTION OF PREFORMED CAVITIES OR SPACES.

EXUDATION CYSTS result when excessive secretion takes place into closed cavities, such as bursæ, cysts, bronchoceles, etc.

RETENTION CYSTS.—These possess a distinct fibrous wall lined with epithelium, and are caused by obstruction of the duct of a gland or portion of a gland, the continuous secretion producing dilatation of the duct or gland-acinus. In most instances, as a result either of inspissation of the contents or of the mingling with them of exudation-products from the cyst-walls, the normal character of the secretion is totally altered. According to their origin, three sub-classes are usually described—viz. (1) *Sebaceous* (atheromatous) cysts, formed by the dilatation of sebaceous glands; (2) *Mucous* cysts, due to the dilatation of mucous glands; and (3) Cysts formed by the *distention of large ducts*—i. e. the salivary, lacteal, hepatic, renal, etc.

(1) SEBACEOUS (atheromatous) CYSTS present themselves as smooth, flattened ovoidal, sometimes semi-fluctuant tumors, usually movable on the deeper parts, but often adherent to the skin. At times the orifice of the obstructed duct can be seen, indicated by a small black spot.

Seats of Predilection.—The scalp and face chiefly, but they may be found on any part of the body, and are often multiple. When situated in the scalp they are sometimes apparently hereditary. Unlike dermoid cysts, the pultaceous, cheesy contents—often of an offensive odor—contain no hairs, while the cyst-wall possesses neither papillæ nor hair-follicles. Certain secondary changes may greatly alter their appearance and obscure the diagnosis. Thus by inflammation a sebaceous cyst may be converted into an abscess: after spontaneous opening the thinned coverings may ulcerate, abundant fungous granulations may form, and the margins and base of the sore may become indurated and elevated, closely resembling epithelioma. These fungous sores may also undergo actual epitheliomatous change: a portion of the coverings ulcerating, the secretion may be gradually forced out, drying as it protrudes, thus in time

forming a cutaneous horn, sometimes inches in length; finally, calcification of the cyst-wall may take place.

Diagnosis.—They are most apt to be mistaken for fatty tumors or chronic abscess. From the former they can be distinguished by the fact that the edge of a cyst does not slip away from the finger when pressed upon, by the absence of dimpling of the overlying skin, and when present by the black punctum indicating the duct-mouth; from the latter, by the absence of symptoms of inflammation and by the use of the grooved needle. When suppuration has occurred, one of the degenerative changes already mentioned, the symptoms of suppurative inflammation, the increase in size, and the exploring needle if requisite, will demonstrate the condition. In those rare instances where a fungating ulcer follows suppuration of a cyst, proper therapeutic measures will cause it to heal in a reasonable time, thus demonstrating that it is not epitheliomatous. If healing cannot be secured, the ulcer has probably undergone epitheliomatous change in whole or in part. When such change has attacked the ulcer before the surgeon sees the case, the diagnosis must depend upon the presence of the characteristics described as indicative of this disease, together with the history.

Treatment.—When situated upon the face, if the orifice of the obstructed duct can be discerned, it may be dilated with a small probe and the contents of the sac pressed out, this procedure being repeated from time to time, thus avoiding any scar; but final success is rarely attained, and the method is of very little value. Complete removal of every portion of the cyst-wall is usually the best treatment, and this can be most readily done by transfixion of the cyst and overlying integument with a curved bistoury, pressing out the contents, and then grasping the edges of the cyst-wall with two pairs of forceps, twisting and pulling out each half. If too adherent for this, careful dissection will be required.

2. **MUCOUS CYSTS** arise from dilatation of mucous glands, their walls being comparatively thin and their contents a viscid mucoid fluid in which cholesterin is sometimes present. They form in the mouth one variety of *ranula*: so-called dropsy of the antrum is sometimes due to cystic dilatation of one of the mucous glands of its lining membrane.

Seats of Predilection.—The lips, mouth, antrum, labia, and indeed wherever mucous glands exist.

Treatment.—Excision of a considerable portion of the cyst-wall, and applications to the interior which will destroy the secreting surface. (See Diseases of the Mouth and Antrum.) Descriptions of cysts formed by the dilatation of such ducts as those of Wharton (forming *ranula*), of the breast (*galactoceles*), etc. will be found in the sections on the diseases of those organs.

3. **EXTRAVASATION CYSTS** result from hemorrhage into closed cavities, as that of the tunica vaginalis testis (hematocele). Some authors describe extravasations into softened portions of solid tumors, or into the cellular tissue which condenses around the effusion, as extravasation cysts.

II. CYSTS OF NEW FORMATION.

(a) **SIMPLE OR SEROUS CYSTS** (Fig. 27) possess a thin wall lined with endothelial cells, and contain a serous or thick mucoid fluid. They originate from effusion, which takes place into the lymph-spaces of the connective tissue from the local irritation of pressure, and push aside the bundles cov-

ered with endothelial plates until they are condensed into a cyst-wall covered more or less completely with endothelial cells: this is the method of formation of an adventitious bursa. Simple cysts of the breast are similarly produced, and possibly some of the neck, although most of these are of congenital origin, while those occupying the median line of the neck arise from effusion into some of the normal bursal spaces of that region—*i. e.* antithyroid or infrahyoid bursæ.

(b) **HEMATOMATA, OR BLOOD-CYSTS.**—There are two varieties, the first being usually found in the cervical region, and consisting of thin-walled cavities containing pure blood: their mode of origin is doubtful, but they appear to have some direct communication with the veins, because if tapped or incised they often bleed profusely. The second variety arises from the mechanical and inflammatory condensation of the tissues around an extravasation of blood, which may eventually be absorbed or undergo so-called organization; or the blood may remain liquid, disintegrate, and be absorbed; or suppuration may ensue. This form results from injury, and is situated most commonly beneath the scalp, especially in newborn infants. (See Cephalhematoma.)

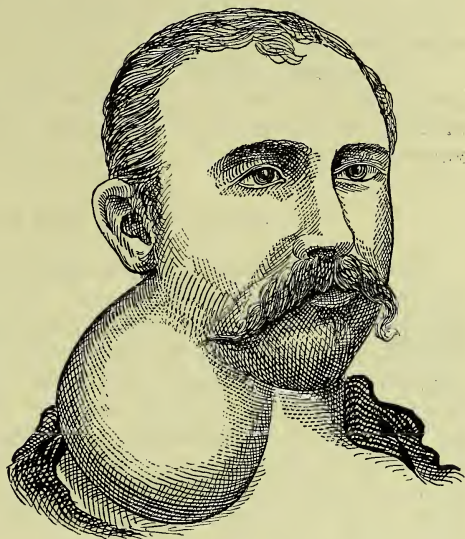
So-called *compound proliferous cysts*, such as those found in the breast and ovary, are merely instances of primary cystic change in these organs, where, as a result of secondary developmental changes, ingrowths occur arising from the cyst-walls.

III. CYSTS OF CONGENITAL ORIGIN.

These result either from inclusion of a portion of the epiblastic layer within the mesoblast, or from the distention of the cavity of some persistent foetal structure which should normally have become obliterated; for instance, broad-ligament cysts developing from the parovarium, and, dermoid cysts, as alleged, by the inclusion of a blighted ovum in either the testicle or the ovary. Since all except **dermoid cysts** of the external parts will receive special mention elsewhere, only this variety of cyst will be here described. The cyst-wall contains hair-follicles and sebaceous glands, while the contents are formed of the secretion of these structures, of disintegrated epithelial cells, and of hairs which have been shed. They often have absolutely no connection with the skin, and, occurring about the face and head where in the embryo fissures exist, are probably the result of inclusion of a portion of epiblast. Similar tumors of the ovary and testicle which contain bone, cartilage, and, in the case of the ovary, teeth, as before said, have been ascribed to inclusion of a blighted ovum, but this is at least non-proven.

Seats of Predilection.—The outer angle of the orbit, over the root of the nose, the ovaries, and the testicle.

FIG. 27.



Serous Cyst of the Neck (original).

Diagnosis.—This must depend upon the detection of a globular, tense, smooth tumor, usually situated at the outer angle of the orbit, unattached to the skin, generally freely movable upon the deeper parts, if overlying the bone often causing its partial or complete absorption, and of congenital origin. Processes of these cysts sometimes extend deeply into the orbit, or even into the cranial cavity. (For Ovarian and Testicular Dermoid Cysts, see the appropriate sections.)

Treatment.—Removal by careful dissection, making the necessary incisions in such a manner, if possible, that they shall coincide with the natural wrinkles of the parts, or that some other structure, as the eyebrow, shall conceal the scar.

IV. CYSTS DUE TO THE PRESENCE OF PARASITES.

The only parasitic cyst of surgical importance—the hydatid—is that produced by the *Tænia echinococcus*, which infests the intestines of the dog. The ova reach the human alimentary tract with the food or water, are there hatched, migrate, reach the blood-current, and lodge in some organ, developing into a hydatid tumor. The external layer of the cyst-wall is composed of a “highly elastic, lamellar cuticle;” the internal layer consists of “granular matter, cells, muscle-tissue, and a water-vascular system” (Sutton). A more or less complete adventitious fibrous capsule isolates the true cyst-wall from the surrounding tissues. Upon attaining the diameter of an inch or more, from the mother-cyst small vesicles or “broad capsules” form, which develop retractile heads or “scolices,” each about 0.3 mm. long, having four “sucking-disks and a circlet of minute, blunt hooklets.” Daughter-cysts form from the “blood-capsules,” and possibly from the “scolices,” the rapid enlargement seen where pressure does not interfere resulting from the increase in number of these capsules and daughter-cysts. Sometimes even large cysts contain neither capsules nor vesicles, being then sterile, but are recognizable by the characteristic lamellation of the cyst-wall. Multilocular hydatids consist of aggregations of innumerable small vesicles—usually sterile—varying in size, few larger than a pea, which are not contained in a mother-cyst. The bones and spinal cord are the usual sites for this variety. Hydatids eventually cease to grow, die, shrivel, and become calcified, leaving only the hooklets to enable the microscopist to determine the nature of the mortar-like mass. Rapid growth of daughter-cysts may produce necrosis of the mother-cyst with rupture. When related to the trachea, stomach, or intestines, pressure-absorption may permit osmosis of gas, fluid, or air; the hydatid dies, septic germs gain access, and suppuration ensues. Hydatids may also rupture into some one of the hollow viscera, a termination to be dreaded, as possibly productive of instant death or secondary changes ultimately lethal, although cure sometimes results.

Seats of Predilection.—Liver, kidney, omentum, bones, thyroid gland, spinal canal, brain, lungs, and connective tissue.

Treatment.—The cyst, when possible, must be removed entire. If total removal is not feasible, incise, evacuate; when possible remove the cyst-wall, leaving the capsule, and carefully drain. Never aspirate or merely puncture *except for diagnostic purposes*.

BOOK II.

SPECIAL SURGERY.

CHAPTER I.

SURGERY OF THE VASCULAR SYSTEM.

SECTION I.—DISEASES OF THE HEART AND PERICARDIUM.

THE diseases of the heart which may demand surgical interference are those which are accompanied by over-distention of the ventricles or by effusion into the pericardial sac. In order to understand how to relieve these conditions by surgical means it is necessary to study the anatomy of the heart and of its covering. In the healthy chest the heart is contained in a space extending obliquely in front from the third to the sixth costal cartilage, and horizontally generally from half an inch to the right of the right border of the sternum to a point half an inch to the right of the left nipple. Posteriorly it occupies the space corresponding to that between the fourth and eighth dorsal spines. The auricles are on a level with the third costal cartilage. The pulmonary artery covers anteriorly the left auricle. The right ventricle is partly behind the sternum and partly to the left of it. The left ventricle, except at its apex, is behind the right ventricle.

The pericardium is a fibro-serous sac in which the heart is contained. The base of the sac is at the diaphragm, and the apex is above and by its fibrous layer is connected with the deep cervical fascia.

OVER-DISTENTION OF THE HEART occurs in cases of pulmonary congestion of an acute character. The operation of *tapping the cavity of the heart* has been suggested with the view of relieving the dangerous condition under which the heart labors. The right auricle is the place selected for puncture, because the position of that cavity is less subject to alteration in its relation to the surrounding parts, and because the antero-posterior internal diameter is greater than that of the ventricle, the walls of which are also much thicker than those of the auricles.

The best place to perform *paracentesis auriculi* is the third intercostal space at the right edge of the sternum. The needle should be thrust directly backward. The operation should be performed as quickly as possible, and in order to abstract a sufficient quantity of blood with celerity it is necessary to introduce an aspirating needle about three times the size of a hypodermatic needle. The needle should be rendered perfectly aseptic before it is thrust into the auricle, and the end of the needle should be attached to the tube of an aspirator, because the blood-pressure is not sufficient to force the blood out through a canula. The needle must pierce the skin and fascia, the edge of the right lung and the pleural sac covering it, as well as both layers of the pericardial sac, before it penetrates the auricle. Tapping the cavity of the heart is fraught with extreme danger, and cannot be commended except in special and unusual cases, and even then should be resorted to only after consultation.

EFFUSION INTO THE PERICARDIUM occurs as a result of acute and chronic pericarditis, both of which conditions may arise from various causes, including traumatism. Usually the effusion is moderate and undergoes absorption. Occasionally, however, the quantity becomes excessive and gives rise to alarming symptoms; under these circumstances tapping of the pericardial sac is indicated.

The **symptoms** denoting great effusion in the sac are precordial oppression, syncope, dyspnea, aphonia, feeble and irregular pulse, difficulty of deglutition, and dilatation of the veins of the neck, in addition to the signs of pericarditis during the different stages. An inspection of the chest shows that the pericardial sac is dilated and that the respiratory movement of the left side is impaired.

The physical examination, if made before the pericardial surfaces are separated by the fluid, demonstrates the presence of a pericardial friction-sound, which must not be mistaken for an endocardial murmur. The distinguishing feature of the pericardial friction-sound is that it does not possess the same regularity of rhythm as an endocardial murmur, and is not propagated beyond the limits of the precordia. Percussion reveals the presence of flatness over an enlarged precordial space both laterally and vertically. The flatness maps out a quadrilateral or a pyriform area with the base below and extending to both sides of the heart-apex. Auscultation demonstrates the absence of vocal resonance and of fremitus, and shows muffling of the heart-sounds. The apex-beat is pushed upward and to the left on account of the effusion, and in some cases it is lost.

Paracentesis pericardii should be employed when the symptoms threaten life. For purposes of positive diagnosis and with a view to ascertaining the character of the fluid an aseptically clean hypodermatic needle can be introduced before tapping, after which an aspirating needle can be used, or even a trocar, according to the consistency of the fluid. The best point for introducing the needle is at the fifth intercostal space, two inches to the left of the left border of the sternum. This will puncture the pericardium external to the internal mammary artery. The direction of the needle should be backward. The fluid should be withdrawn very slowly, and the effects of the removal of the effusion carefully watched. The operation should of course be done under the strictest antiseptic precautions.

Incision and drainage of the pericardium has been employed in cases of empyema of the pericardial sac. The incision, irrigation, and drainage of the sac should be resorted to only in the purulent form of the exudation. The operation should be performed at the same point as *paracentesis pericardii*. If necessary, part of a rib may be resected. Although this operation has as yet been done but seldom, the great mortality of empyema of the pericardium warrants its performance.

SECTION II.—INJURIES OF THE HEART AND PERICARDIUM.

RUPTURE OF THE HEART has followed complete obstruction of one of the branches of the coronary arteries, the obstruction having been caused by a thrombus or by an embolus in the artery. Mechanical distention of the heart has caused rupture, as when its cavities have suddenly been filled with blood escaping from a bursting aneurysm, or when an abscess of the cardiac walls has burst into the ventricles. Rupture of the heart has also been a cause of death in tetanus.

WOUNDS OF THE HEART are not infrequent. These may result from severe

injury of the chest-wall, or from penetration by a fragment of a fractured rib, or by a stab or a gunshot wound. A wound of the heart is not necessarily fatal, as is shown in the case where a needle was removed by Callender from the substance of the heart. Other cases of like nature have been reported by Hahn, Agnew, Stelzner, and others.

The **symptoms** of wound of the heart are not characteristic. Hemorrhage is usually present, but a stab wound may occur with little or no hemorrhage. The absence of hemorrhage is due to the anatomical arrangement of the muscular fibers of the heart. Pain is present as a constant symptom, and attacks of syncope occur at frequent intervals. If hemorrhage has taken place into the pericardium, the percussion note is flat and its area is increased, owing to the presence of the fluid, and the heart-sounds are less distinct than normal.

The cause of sudden death in wounds of the heart may be syncope from pressure on the heart due to over-distention of the pericardium with blood; or the inability of the heart to contract, owing to the wound of the cardiac wall, may produce fatal cerebral anemia. Shock and pulmonary anemia also have caused death in cardiac wounds. Death is not always sudden, but may be deferred for hours (Agnew).

TRAUMATIC CARDITIS AND PERICARDITIS.—The results of inflammation of the walls of the heart have been observed in cases of injury of the organ where the patients have died after a fortnight. In these cases the substance of the heart was studded with inflammatory exudates.

Inflammation of the pericardial sac is a more frequent result of traumatism than inflammation of the heart itself. The physical signs of a pericarditis of traumatic origin are substantially identical with those of an ordinary pericarditis.

The **treatment** of wounds of the heart and of traumatic carditis and pericarditis includes constitutional as well as local measures. The patient should lie with the head low, in order to prevent syncope from cerebral anemia. Absolute quietude should be insisted upon, and opium should be administered with a view to control subsequent inflammation, to tranquillize the circulation, and to relieve pain. Artificial warmth should be applied if indicated by the presence of collapse. It must not be overlooked that a certain amount of collapse is a favorable condition through its influence in checking hemorrhage and inflammation, and that over-stimulation must be carefully guarded against. In some cases violent reaction follows and necessitates the administration of cardiac sedatives.

If a patient survives beyond the period of reaction, the stage of inflammation ensues. This condition must be treated in the same manner as a pericarditis depending upon idiopathic causes.

SECTION III.—DISEASES OF THE BLOOD-VESSELS.

PART I.—DISEASES OF THE VEINS.

Before discussing diseases of the veins it is necessary to review some points in the anatomy of the vessels. A vein, like an artery, has three coats. The internal coat of the veins is the same as the internal coat of the arteries, and its continuation forms the only coat which the capillaries possess. The middle coat is composed of longitudinal and circular elastic fibers, interlacing with which are involuntary muscular fibers that are not so abundant in the veins as in the arteries. The external coat is composed chiefly of white fibrous tissue. The coats of the veins differ from those of the arteries in the thinness of the mus-

cular coat and in the presence of valves in the internal coat of the superficial and a few of the deep veins; they correspond with those of the arteries in the presence of a common external fibro-cellular tunic and the internal endothelial coat. The thinness of the muscular coat of the veins prevents them from having that rotundity, elasticity, and contractility which are so characteristic of the arteries; it also permits the temporary distention or bulging of the vessels when there is some mechanical impediment to the free return of venous blood to the heart. To serve this purpose the veins possess an inherent capacity of limited distention which is never required in the case of the arteries. It is important to remember this fact when the subject of wounds of veins is considered. Notwithstanding the thinness of the walls of the veins, they are relatively as strong as those of the arteries.

The presence of valves is a peculiarity of veins. These valves support the column of blood mechanically. They are found in the superficial venous system, and especially in the lower extremities. In the portal and hemorrhoidal systems there are no valves; and this fact has an important influence upon the development of certain diseases in connection with these veins.

I. INFLAMMATION OF VEINS, OR PHLEBITIS.—Inflammation of a portion of a vein produces changes in its coats in the same manner as inflammation of the coats of an artery alters the arterial coats. The disease is much more common than arteritis. Phlebitis may be acute or subacute.

ACUTE PHLEBITIS is diffuse, and is the result of some irritation of a vein, as puncture or any other injury accompanied by infection; sometimes it follows the ligation of a vein in its continuity or after an amputation. It especially follows any septic traumatism, and is then very dangerous, leading generally to pyemia.

SUBACUTE PHLEBITIS is circumscribed, and is not ordinarily so dangerous as the acute diffuse form. The subacute variety generally supervenes upon some chronic disease of the coats of the vein which has led to their thickening by deposit of fibrinous matter, thus occluding the vein. An abscess may develop, and must be opened as an ordinary abscess. There is no hemorrhage from the vein, as it has been blocked up by external pressure or by an intravenous inflammatory product; hence its lumen does not communicate with the abscess. Should the fibrinous deposit break down, micro-organisms and their ptomaines get into the vein, and acute diffuse phlebitis is engrafted upon the chronic variety and pyemia results.

The symptoms of phlebitis are pain and tenderness along the course of the vein, with discoloration of the skin and acute oedema below the obstruction. There are present also symptoms of a constitutional nature, such as rapid and irritable pulse, rigors, elevation of temperature, dry and brown tongue, and pain in the joints if pyemia has developed.

Treatment of Phlebitis.—The patient should be kept perfectly quiet, the affected limb elevated, so as to favor the return circulation, and leeches applied in certain cases along the inflamed veins. Goulard's extract or a lead-and-opium wash should be used, or hot antiseptic fomentations, if a circumscribed abscess is forming. Opium is indicated to relieve pain. Abscesses should be opened, for if they are not incised the micro-organisms and the ptomaines may break down the plug in the vein and the softened thrombus obtain access to the general circulation. The patient's general condition must be kept up with nourishing food and stimulants, as there is a great tendency to exhaustion following certain forms of phlebitis.

II. VARIX, OR VARICOSE VEINS.—By this is meant an enlarged, elongated,

tortuous, knotty condition of the veins. The term "varicose veins" is restricted in general use to the veins of the extremities, and especially to those belonging to the lower extremity. The internal saphenous vein is the one most frequently affected (Fig. 28). The disease begins by a slow dilatation of the vein, which gradually becomes thickened and tortuous. The inner lining membrane, or endothelial coat, of the vein is altered, and the valves are shortened, and thus rendered insufficient to support the column of blood. Besides these alterations in the inner coat of the vein, the outer coat becomes thickened on account of the connective-tissue infiltration and of the inflammatory new formation (periphlebitis).

The varicose condition affects, as a rule, chiefly the superficial veins. When these are largely dilated the circulation becomes sluggish and is carried on by the deep veins. Occasionally it happens that the deep veins are primarily affected. Instead of the outer coat of the vein being thickened, this coat sometimes becomes excessively attenuated, and separates at places, so that the internal coat protrudes through the slit and forms a protrusion which may even become pedunculated. This pathological condition is, however, rare. When the varicose veins begin where the venous radicles arise from the capillary system, the varicosity appears as a fine capillary injection with an

FIG. 28.



Varicose Veins of the Legs and Left Thigh (original).

When the varicose veins begin where the venous radicles arise from the capillary system, the varicosity appears as a fine capillary injection with an

arborescent appearance. This condition is more frequently found in women. When the large trunks are affected, the veins are dilated, tortuous, and knotty. They rise above the level of the skin, and if pressure is made over them the presence of blood in the vessels becomes at once manifest. When the disease has existed for a long while, they may burst from excessive thinness of the coats, and a serious or even fatal hemorrhage may result. Again, instead of the veins standing out boldly above the skin-level, there may be a passive exudation into the surrounding cellular tissue of the limb, which causes it to become œdematous. This is not the ordinary œdema from obstructed venous return, but a solid non-resisting œdema, which has a marble-like appearance and does not pit upon light pressure. Upon this peculiar œdematous condition there is often engrafted a most obstinate eczema. If the eczema is allowed to progress without any treatment, it will degenerate into a superficial ulceration which will become chronic and may extend down into the tissues and give rise to "varicose ulcer." These ulcers may involve a vein and give rise to fatal hemorrhage.

There is another condition arising from the presence of varicose veins which does not appear until late in the progress of the disease. *Thrombi* may be formed within the vein, which may become disintegrated and break down, forming an abscess, if infection takes place (suppurative thrombo-phlebitis), or under certain conditions they may organize and completely occlude the vein (plastic thrombo-phlebitis), and thus bring about a radical cure. The thrombi may also become shrunken and contracted, and frequently laminæ of fibrin are deposited upon them. Small hard concretions which have been called *vein-stones* or *phleboliths* have been observed. These are formed of laminated fibrin, phosphate of calcium, and the sulphates of calcium and potassium.

Varix of the internal saphenous vein (Fig. 28) may give rise to symptoms similar to those of femoral hernia. In varix there is a tumor at the saphenous opening at the place where a femoral hernia presents. The varix disappears when the patient assumes the recumbent position, as in femoral hernia. Both swellings reappear upon the patient's coughing or assuming the upright position. The differential diagnostic point is that in varix of the saphenous vein, if pressure is made at the saphenous opening while the patient is in a recumbent position, the swelling will reappear when he assumes the upright position, even though pressure is maintained. In femoral hernia, on the other hand, the tumor will not reappear under the same conditions.

The **causes** of varicose veins are—I. Predisposing, and II. Exciting.

I. Among the predisposing causes may be mentioned—

(a) *Sex.* Varicose veins are most frequent in the female, and are apt to follow uterine enlargement from any cause.

(b) *Age.* The tendency to the production of varicose veins increases as age advances.

(c) *Obstruction* to the free return of blood in the veins, as tight garters worn below the knee or other constrictions obstructing venous circulation.

(d) *Occupations* which require habitual standing.

II. Among the exciting causes may be mentioned—

(a) *Tumors* in the abdomen or pelvis. It is evident that any obstruction to the return venous circulation has a tendency to develop varicose veins; thus, tumors of any variety which press upon the iliac veins will give rise to varicose veins of the leg. It has been stated that the left leg is more frequently the seat of this disease than the right, on account of the sigmoid flexure, which when distended presses upon the left iliac vein. The cæcum, however, when distended, would press nearly as much upon the right iliac vein, and as a clinical fact the right leg is affected with equal frequency.

(b) *Diseases of the Heart and Lungs*.—In these conditions there is found an important exciting cause. If the heart is feeble in action, the power to drive the blood back is lessened, and as a consequence the column of blood moves very slowly and becomes stagnant in places. The development of the ascites (hydroperitoneum) often incidental to heart affections also forms by pressure upon the veins a barrier to the free return of the venous blood.

(c) *Pregnancy* by pressure of the gravid uterus upon the iliac veins. In a first pregnancy the veins of the extremities are not much altered pathologically, and if attention is paid to this incipient stage of the disease, which is amenable to treatment, subsequent pregnancies will not be so likely to produce an incurable condition of varicose veins.

Treatment.—I. *Palliative*, and II. *Radical*.

Palliative treatment is to be directed to the removal of the causes of the obstruction and also of their effects, as far as possible, without an operation. This object is best fulfilled by attention to the condition of the bowels, to the state of the liver, to the affections of the heart and lungs; by enforcing quiet and rest in a recumbent position, which favors venous return circulation, and by attention to the general health, and often by out-door exercise in a suitable climate. The local palliative treatment consists in the application of an elastic bandage or a perfectly-fitting silk elastic stocking which shall afford support to the vessels, thereby equalizing the circulation. This elastic support has a tendency to turn the flow of venous blood from the superficial veins into the deep veins, which do not, as a rule, become varicose. The silk stocking should be made to order from accurate measurement of the limb, and should extend from below at the toes, where the trouble begins, to or above the knee, where it should be loose.

The *radical treatment* has for its object the complete obliteration of the vein. Many surgical procedures have been devised for this purpose.

Of these methods, the multiple ligatures, as advocated by Dr. Charles Phelps, who ties the vein in thirty or forty places, and excision of the vein in six, eight, or more places, are the best. All such operations on veins must be done with the most stringent antisepsis, or an acute septic phlebitis and pyemia may readily follow.

III. *NÆVUS*.—This is an affection of the capillaries and the veins. When the nævus affects the *capillaries* there is a slightly elevated area of skin of a scarlet or purple color. Nævi are situated sometimes upon the trunk, but generally upon the face. They vary in size from that of a pin's head to that of a silver dollar, or even may involve an area nearly as large as the hand. They produce an unsightly appearance, but seldom give rise to any physical discomfort unless they undergo ulceration, in which event a troublesome and in some cases even alarming hemorrhage ensues. The vessels consist of capillaries held together by areolar tissue. The term *telangiectasis* is often applied to this form of nævus, and it is popularly called *mother's mark* (Fig. 29).

The nævi formed of *veins* are found beneath the skin as well as in the skin. They are also seen in the orbit, the liver, and other viscera. They pulsate, and are much larger than the capillary nævi. They can be made partially to disappear by pressure, but reappear when the pressure is discontinued. The anatomical structure is similar to that of carcinoma, but instead of the spaces

FIG. 29.



Nævus (original).

being filled with epithelial cells they contain blood. They are painless. If punctured they give rise to alarming hemorrhage. This form of nævus is termed *cavernous angioma*.

Treatment.—The operations for the removal of nævi are many. The best recognized surgical treatment includes ligation, excision, electro-puncture, the cautery, and coagulating injections.

Ligation is done by passing a pin under the mass and throwing a ligature around the base of the nævus below the pin. If large, a double ligature can be passed under and at right angles to the pin, and then the nævus is tied in two halves. This and excision are the best of the above-mentioned methods. Setons lead to what may be a dangerous suppuration, and coagulating injections may produce extensive thrombosis or distant embolism, and thus cause death. Nævi about the face and scalp should never be injected, on account of the danger of thrombi and emboli. In large cavernous angiomas electrolysis and excision have been employed with good results.

PART II.—DISEASES OF THE ARTERIES.

ARTERITIS.

I. The word *arteritis* signifies inflammation of an artery. Each coat of an artery may be primarily separately inflamed. Thus we distinguish inflammation of the internal coat, of the middle coat, and of the external coat. These inflammations are called, respectively, *Endarteritis*, *Mesarteritis*, and *Periarteritis*. All these different varieties may be either *acute* or *chronic*.

1. ACUTE ARTERITIS.—This is a rare surgical disease, and is due to an inflammation excited by an infectious or poisonous embolus lodged in the artery. The internal coats become swollen and infiltrated with pus-cells. The suppurative inflammation is transmitted to the other coats of the artery and to the surrounding parts, and may result in abscess.

ACUTE PERIARTERITIS is also usually secondary in origin, and is due to an extension of inflammation from the surrounding parts. The exudation is apt to be purulent. In these destructive inflammations of the arterial coats the lumen of the artery generally becomes occluded by a thrombus before perforative ulceration occurs. Should this thrombosis not occur, severe and sometimes fatal hemorrhage may arise if the artery be of sufficient size.

It is still an open question whether acute arteritis occurs as a primary affection. A few doubtful cases have been recorded in which severe pain and tenderness existed along the course of an artery, in some instances accompanied by a certain amount of redness and swelling. The diagnosis of acute arteritis has been made, but, as the termination has been favorable, the pathological proof of its existence is wanting.

2. CHRONIC ARTERITIS.—This is the *atheroma* of most authors, and its relation to the production of aneurysm is a subject of great surgical interest. By atheroma is meant a chronic inflammation of the internal coat characterized by a fatty degeneration, with a tendency to cheesy collections and calcareous deposits. The middle coat is not usually involved until late. The external coat becomes affected secondarily, and is hypertrophied and inelastic. As a result of the fatty degeneration the inner coat of the artery swells, the circulation is disturbed in that part, and an ulcer is formed by the rupture of a caseous mass into the lumen of the artery.

Traumatism affecting the artery, alcoholic excesses, syphilis, Bright's disease of the kidney, gout, and rheumatism are among the diseases which are

recognized as the causes of atheroma. This condition ordinarily involves the larger arteries, and in this respect differs from syphilitic arteritis, which, as has been pointed out, affects chiefly the vessels of smaller size. Occasionally the lime-salts are deposited in the ulcer and a calcareous plate is formed. Atheroma is usually seen in persons of advanced age.

Calcification of the artery consists in a low grade of inflammation in the middle coat, and is characterized by the deposit of earthy matter, chiefly carbonate of calcium and the phosphates. This deposit may be in plates, and it is then termed laminar calcification, or it may be arranged in a concentric manner around the muscular fibers, when it is termed annular calcification, and when the latter form is spread over a considerable area it is termed tubular calcification. This disease affects arteries in the extremities, and as a result the parts beyond are inadequately supplied with blood, owing to the narrowed lumen of the vessel and to its loss of elasticity. When the disease is extensive enough completely to occlude the artery, gangrene of the limb may result. When it affects the vessels in the extremities, the calcification can be readily recognized by the finger placed upon the vessel. This is often observed in the radial artery, the vessel becoming roughened and rigid and hard like a pipe-stem.

The treatment of arteritis depends upon the variety. If due to syphilis, the iodides and mercury are useful; if to rheumatism or gout, the remedies that are indicated in these affections should be employed. Little can be done to cure the disease, and the treatment should be directed toward the prevention of any extension of the inflammation. Great importance must be attached to the avoidance of all kinds of violent exercise, which might lead to rupture of the vessel with its attendant consequences.

ANEURYSM.

The word *aneurysm* is derived from the two Greek words *ἀνά*, "through," and *εἰρύνω*, "I widen."

An aneurysm is a tumor containing blood and communicating with the interior of an artery. There are some forms of blood-tumor which do not strictly come within the limits of this definition. These will be discussed before taking up aneurysm proper.

The first variety is *ARTERIAL VARIX*. This consists in an elongation and dilatation of a single artery of medium or small size. The vessel is pouched, sacculated, and tortuous. This condition is similar to that of a varicose vein. The superficial temporal, occipital, and posterior auricular arteries are often the seat of this disease. The skin over the dilated vessel is exceedingly thin, or even ulcerated, and this condition may give rise to alarming hemorrhages.

CIRSOID ANEURYSM is the next variety, and consists in a dilatation and elongation of a number of arteries of medium and small size.

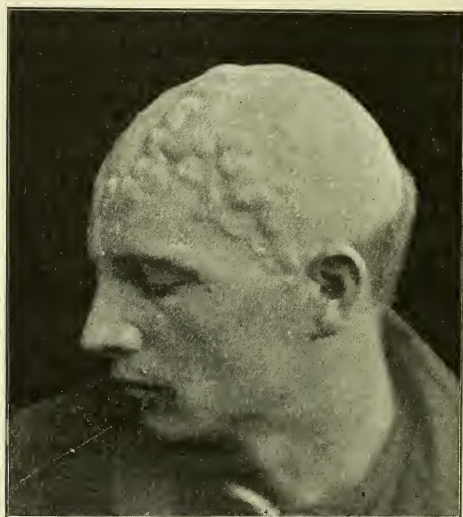
If a *single* artery is involved, and it is pouched and tortuous and dilated after the same manner as a varicose vein, the term *arterial varix* is applied.

If a *number* of arteries held together by connective tissue are affected by these pathological changes, the tumor is called a *cirroid aneurysm* (Fig. 30). Such an aneurysm usually involves also the capillaries in its immediate vicinity. The cause of this disease is supposed to be an injury in which the vasomotor nerves have been paralyzed. The tumor thus formed is irregular in shape, compressible, bluish in appearance, and pulsating in character. The temperature within the circumscribed area of the outgrowth may be elevated on account of the increased vascular supply. Cirroid aneurysm is distin-

guished from a true aneurysm by the situation of the growth, the number of vessels involved, the superficial bruit and pulsation, the peculiar spongy, doughy feel, and the difference in the pressure-effects.

The treatment of cirroid aneurysm is usually unsatisfactory, and often attended with great danger from hemorrhage. The lack of success in treatment is in part due to a lack of comprehension of the nature of the disease.

FIG. 30.



Cirroid Aneurysm (original).

Extirpation, the lines of incision being carried wide of the tumor, multiple ligation of the individual afferent arteries, the application of the galvano-cautery, the injection of coagulating fluids, the introduction of the electro-puncture needle alone or associated with circular compression of the afferent vessels, acupressure of the main feeding artery, and ligation of the main trunk, are among the recognized methods of treatment; often two or more of these may be combined with advantage.

Preliminary ligation of afferent vessels followed by cutting the tissue around the tumor has proved curative. Removal by excision is the only method which offers a reasonable certainty of cure, and this operation should be immediately preceded by the ligation of every tributary. Bad cases of cirroid aneurysm of the hand require amputation.

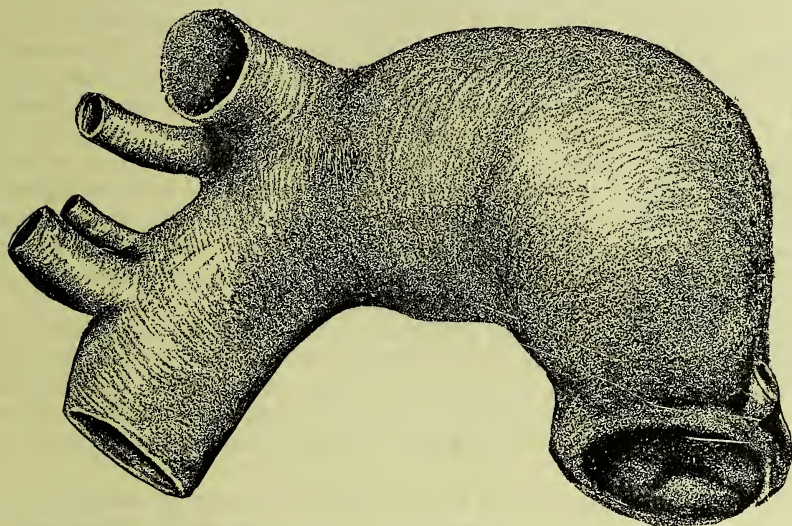
All aneurysms may be divided into two groups—the *idiopathic* and the *traumatic*. In the idiopathic variety there is a sac formed of one or more of the arterial coats, and the blood within the sac is in direct communication with the lumen of the artery. In the traumatic variety there is also a sac, but its walls are composed of inflammatory lymph and a proliferation of the connective-tissue cells.

Idiopathic aneurysms are divided into—

1. Tubulated.
2. Sacculated, $\begin{cases} a, \text{ true,} \\ b, \text{ false,} \end{cases} \begin{cases} 1, \text{ circumscribed.} \\ 2, \text{ diffused.} \end{cases}$
3. Dissecting.

The *tubulated aneurysm* (Fig. 31) is the *fusiform aneurysm* of some authors. In this variety the three coats of the artery are simultaneously dilated, in the

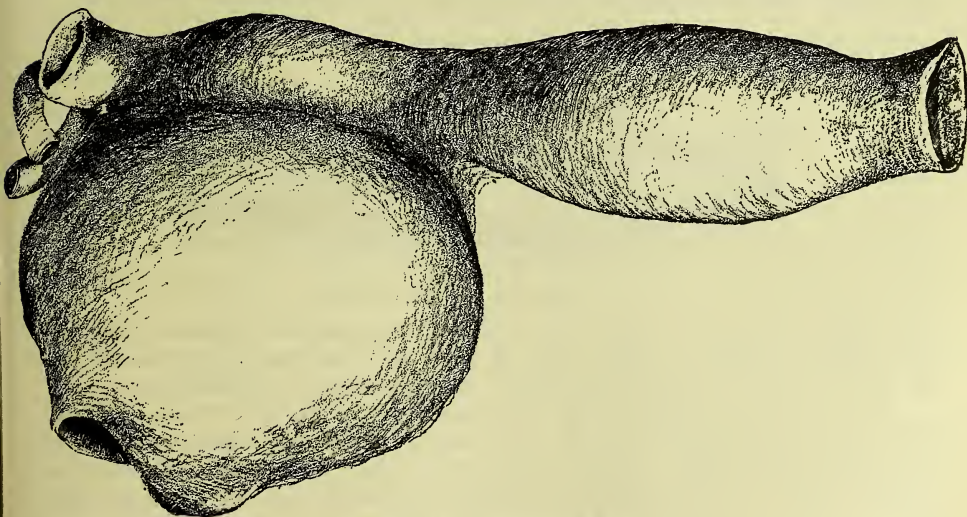
FIG. 31.



Tubulated or Fusiform Aneurysm (original).

circumference as well as in the length of the vessel. The middle coat is not preserved as a continuous layer, but its elements are separated. This aneurysm

FIG. 32.



Sacculated Aneurysm (original).

is found in the cranial, thoracic, and abdominal cavities. The tubulated aneurysm rarely grows to be of any size, and scarcely ever ruptures unless a sacculated aneurysm is engrafted upon it. The sac in this form of aneurysm seldom

contains any laminated fibrin. It, however, gives rise to great discomfort, and often causes severe pain by pressure upon important organs.

The *sacculated aneurysm* (Fig. 32) is one which projects from a tubulated aneurysm or which springs from the side of an artery, the interior of which is in communication with the sac by an opening which is called the mouth.

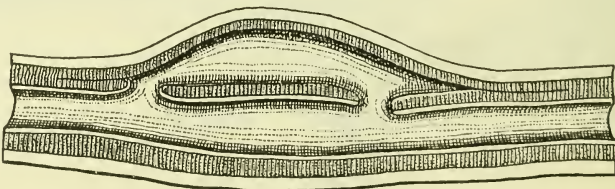
The sacculated aneurysm is subdivided into *true* and *false*. The *true sacculated aneurysm* is one in which all three of the coats of the artery are equally expanded to form the sac. It seldom grows larger than an orange.

In the *false sacculated aneurysm* the inner layer is the thickened and altered intima enlarged by successive additions so as to cover the vastly increased surface; traces of the middle coat are to be found only near the neck of the sac; the wall is mainly formed by the condensed and multiplied connective tissue of the surrounding parts. In short, the wall of the aneurysm contains little or nothing of the original wall of the artery, except that its internal layer is continuous with and similar in character to the intima. This variety of aneurysm may grow to an enormous size.

False sacculated aneurysms are subdivided into the *circumscribed*, in which the blood is confined within a sac composed of some part of the arterial coats, and the *diffuse*, in which the sac is ruptured and the blood has extravasated into the neighboring tissue; or else the sac is ruptured, and the blood is confined within a cavity the walls of which consist of lymph and condensed areolar tissue.

The *dissecting aneurysm* is one in which the internal coat of the artery has given way, owing to some erosion caused by an atheromatous patch, and the blood dissects or makes its way through the middle coat (Fig. 33). The blood may burrow for some distance through the middle coat until it comes in contact with an eroded patch situated upon the outer coat, through which it bursts, and finally extravasates into the surrounding areolar tissue; or it may burrow for some time through the substance of the middle coat until it comes in contact with an eroded patch situated upon the internal coat, and then the

FIG. 33.



Plan of a Dissecting Aneurysm (Holmes).

blood again enters the artery; or it may burrow for some distance and meet no eroded patches in either outer or inner coat, and may thus remain in a small sac formed by the circumscribed separation of the arterial coats.

The *component parts* of an aneurysm are (1) the sac, (2) the contents. The *sac* is composed of one or all three coats of the artery, unless the aneurysm is traumatic, in which case the walls are formed by lymph and condensed areolar tissue. The sac may be formed by the internal and external coats, the middle coat having been ruptured; or by the dilatation of the external coat, the internal and middle coats having been ruptured; or by the dilatation of the internal coat, the middle and external coats having given way. If the latter condition is ever present, which has been denied, the aneurysm would be called an *aneurysmal hernia*. The *mouth* of the sac is the narrow opening

which establishes a communication between the interior of the sac and the lumen of the artery from which the aneurysm develops.

In the fusiform aneurysm there is no mouth, as the aneurysm results from a uniform dilatation of the coats of the artery. In the sacculated variety a mouth is present, and its situation relative to the lumen of the vessel influences the amount of fibrin deposited, as well as the growth of the aneurysm.

The *contents* of the sac vary according to the stage of the disease. In the first stage the sac is very thin, and contains only fluid blood. In the second stage the wall of the sac is very thick, and contains fluid blood in the center and laminæ of fibrin (Fig. 34) around the periphery.

The blood is in greater proportion than the fibrin at first, but later the coagulum or laminated fibrin is in excess of the fluid blood. These laminæ of fibrin vary in firmness and consistency in the different parts of the sac. Thus upon the extreme periphery the layers of fibrin are dry, friable, and opaque, while the layers approaching the center of the tumor are soft and of a reddish color.

In the sacculated variety the fibrin is rapidly deposited, and the rapidity with which it is formed depends upon the relation of the mouth of the sac to the sac itself. The greater the obstruction to the free flow of blood into the sac, the greater the tendency to the deposition of fibrin.

In the fusiform aneurysm, where there is no retardation in the current of blood owing to the absence of a mouth in the sac, there is no deposition of fibrin, or at least it is deposited in exceptional cases only.

The *natural terminations of aneurysm* are—(1) *spontaneous cure*, (2) *death*.

The *spontaneous cure of aneurysm* is occasionally effected by nature unaided by the surgeon. Such a case occurs very seldom, but that a cure under certain conditions may thus be brought about is no longer open to dispute. In the cases of spontaneous cure the aneurysm has always been found solid and firm,—which leads to the belief that a deposition of fibrin had already taken place. A deposition of fibrin takes place in consequence of the slower current in the sac, and finally fills it. The clot thus formed within the sac may extend into the vessel, and thus add to the permanence of the cure. Occasionally the aneurysm is spontaneously cured by an embolus, when a clot is washed out of the sac into the efferent artery and occludes it, so that the current is completely arrested within the sac; the latter then fills with a firm coagulum. Sometimes a spontaneous cure is effected when the sac becomes large enough by its own weight to cause mechanical pressure upon the artery sufficient to retard, or even to arrest, the circulation in the vessel. Finally, a spontaneous cure is accomplished in some cases when the sac becomes acutely inflamed and the coagulation of the blood within it is thereby promoted.

Death is the other natural termination. There are various ways by which an aneurysm destroys life: 1st. By *rupture of the sac*. The aneurysm extends to the surface of the body or to a mucous canal or a serous cavity. When the aneurysm has reached the surface of the body the thin skin over the sac sloughs, and when the slough comes away there is a slight hemorrhage through a small opening. This hemorrhage is arrested by a coagulum, but after a while is renewed, until finally the patient dies from repeated hemorrhages. In case an aneurysm bursts into a mucous canal the process is the same. The rupture

FIG. 34.

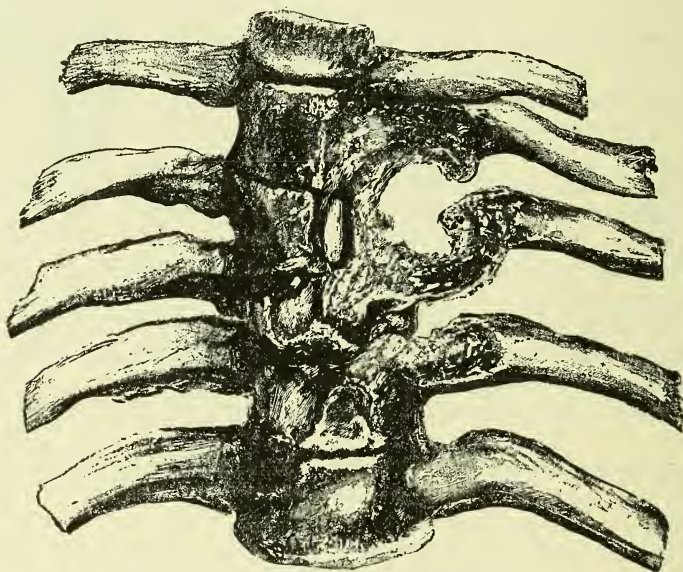


Laminated Coagulum (Key and Bryant).

may open into the trachea, œsophagus, intestine, or bladder. Here, again, the sac is first rendered thin by absorption, and when the slough separates the hemorrhage occurs. An aneurysm may destroy life by bursting into one of the pleural cavities, generally the left, or into the peritoneal or the pericardial sac. In this situation the serous membrane gives way in a rent, and death follows instantly.

2d. Aneurysm also destroys life by *pressure upon important organs*. If the aneurysm presses upon the trachea or the bronchi or the lungs, it produces asphyxia; if upon the œsophagus or the thoracic duct, it causes inanition; if upon the vertebræ and the ribs, absorption of these bones results (Fig. 35), followed by spinal irritation and meningitis, with severe neuralgia from pressure on the intercostal nerves.

Fig. 35.



Absorption of the Vertebræ and Ribs from Pressure by an Aneurysm (original).

3d. Aneurysm, again, destroys life by *septicemia* and *pyemia*, due to acute inflammation and suppuration of the sac; also, 4th, by *embolism*, in which case the small migratory clot is carried by the cerebral arteries to the brain if the situation of the aneurysm is in the arch of the aorta; finally, 5th, by *gangrene* of the extremity caused by obstruction. In this case the gangrene causes blood-poison and death results from septic infection.

Etiology of Aneurysm.—In general terms, any disturbance of the proper relations between the force of the heart on the one hand and the elastic resistance of the artery on the other, especially if an increase of the former is combined with a diminution of the latter, will give rise to aneurysm.

The causes of aneurysm may be divided into I. *Predisposing*, and II. *Exciting*.

I. *Predisposing Causes*.—(a) *Degeneration of the Arterial Coats*.—This is the principal predisposing cause, since in some form it is always present except in traumatic aneurysm. The degeneration most commonly associated with the development of aneurysm is the atheromatous and fatty, frequently accompanied by a calcareous deposit that renders the vessels less elastic. As a result of this atheromatous and fatty condition the artery fails to contract after the

systolic action of the heart, gradually yields and dilates, until finally an aneurysm is formed. It is held by Von Recklinghausen and others that the influence of atheroma upon the development of aneurysm has been exaggerated. It is believed that changes in the middle coat, either inflammatory or degenerative, are among the most frequent predisposing causes.

(b) *Syphilis* is a frequent predisposing cause of aneurysm, in consequence of the changes in the arterial walls.

(c) *Over-action of the Heart*.—Hypertrophy of the heart, by increasing the strength of the impulse, drives the blood with greater force into the arteries. These are likely to distend under the impulse of an hypertrophied heart if they have undergone the slightest degenerative changes. Hypertrophy of the heart associated with chronic nephritis, in which the arterial tension is increased and the vessels are weakened by atheroma, affords another illustration of the combined action of these two causes.

(d) *Certain violent occupations*, as riding and hunting, it has been asserted, predispose a patient to aneurysm. Thus coachmen and postilions, owing to the nature of their occupations, are especially liable to the disease. This clinical fact is explained by the obstruction of the popliteal arteries on account of the constant bending of the knee in horseback riding and sitting on the box, as well as by the contractions of the gastrocnemii and solei muscles when the feet are placed firmly against the footboard or the stirrups. The arteries, too, are bent or stretched in these positions, and the jar and motions of the rider or driver must increase the force of the circulation.

(e) *Age*.—This has a marked influence. Aneurysms are most frequently found between the ages of thirty and forty years, because the arteries begin to lose their elasticity at this period, while the heart has not yet lost any of its force or the muscles any of their strength. Aneurysms in very young people are merely surgical curiosities.

(f) *Sex*.—Seven to one of the entire number of aneurysms are found in males, presumably because of their more active occupations.

II. *Exciting Causes*.—(a) A partial *rupture* of one or more of the arterial coats, produced by external violence, is without doubt a prominent cause of aneurysm.

(b) A direct *wound* of an artery also produces aneurysm, since it leads to extravasation of the blood from the artery into the surrounding tissues. In this case the aneurysm is termed *traumatic*, because the sac is not formed by the coats of the artery.

(c) *Fractures* and *dislocations* are exciting causes of aneurysm, since the artery is torn or stretched so as to weaken the coats, thus permitting subsequent dilatation.

(d) *Strains* have been considered exciting causes of aneurysm, since they produce irregular and forced action of the heart. Strains may also act directly upon the vessel by forcing blood through it while it is under unusual tension, thus causing pressure at right angles to the axis of the vessel, or by stretching the artery in its long axis.

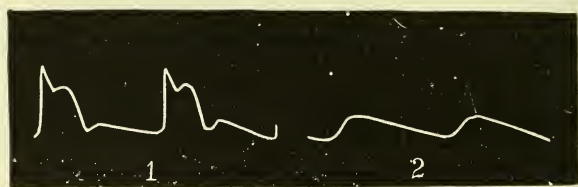
The **signs and symptoms of aneurysm** may be described as belonging to two stages: *First Stage*.—This includes the period from the beginning of the formation of the aneurysm until the tumor is firm from the deposit of fibrin. *Second Stage*.—This includes the period after the aneurysm has become firm and resisting by reason of the presence of the deposit of laminated fibrin. This stage may be absent, as in some aneurysms no such deposit takes place.

First Stage.—(a) *Pulsation which is distinct, expansile, and synchronous with the action of the heart*.

The pulsation is distinct in the first stage, because the aneurysm contains only fluid blood and the sac is thin. The pulsation is excentric and expansile in character. If both hands are placed upon the sides of the tumor, they will be separated from each other with every pulsation. The pulsation in this stage is simultaneous with the contraction of the heart. The pulsation of an abscess lying on an artery would be up and down in mass, and not expansile.

(b) *Pressure on the artery above the tumor diminishes the size of the latter; when applied below the tumor increases its size; and in both cases causes the pulsation to diminish or cease.* If the artery above the sac is compressed, the flow of blood into the sac is arrested, the blood can be squeezed out of the sac, and the tumor disappears. This can be beautifully illustrated in the first stage while the contents of the sac are composed of fluid blood and the walls of the sac are thin. If, after having compressed the artery above the sac and emptied the latter of blood, the hands are placed firmly over the sac and the pressure is removed from above, the blood will rush into the sac, and as soon as the sac has filled pulsation will return and will separate the hands. In abscess, on the other hand, the instant the pressure from the artery above is relieved, the transmitted pulsation, or upheaval, is felt. If the artery below the sac is compressed, the sac will rapidly enlarge and the pulsation will diminish or cease. If the pulsation in the efferent artery at some distance from the sac on its distal side be felt, it will not be simultaneous with the pulsation of the corresponding artery of the opposite side of the body. Besides the appreciable delay in pulsation as compared with the opposite artery, the force of the pulsation will be markedly diminished. The sphygmographic tracing of the pulse upon both sides of the body will also reveal a wide difference (Fig. 36).

FIG. 36.



Sphygmographic Tracings of the Radial Pulse of a Patient with Aneurysm of the Right Brachial Artery: 1, Left Radial Pulse; 2, Right Radial Pulse (Mahomed).

(c) A *bruit* is heard over the aneurysm, and also along the artery for some distance from the sac. The bruit is a noise caused by the rush of blood into, through, and out of the sac, the internal lining membrane of which is roughened. The bruit is blowing or loud and rasping like the noise made by a saw. This blowing murmur is not always present, but its absence will not exclude the possible existence of an aneurysm. In malignant vascular tumors the bruit is sometimes present, but is heard only over the area of the tumor, and is never transmitted along the artery leading from the sac, as it is in aneurysm.

Second Stage.—This stage includes the period after the aneurysm has become firm and resisting by the deposit of laminated fibrin.

(a) *Indistinct Pulsation.*—When the aneurysm becomes firm and its sac is lined with fibrin, the pulsation is indistinct and may even be altogether lost. There are certain points over the sac where the pulsation is felt more distinctly than at others. This is because the fibrin is not equally distributed over the interior of the sac.

(b) *Pressure.*—Owing to the deposition of fibrin, the tumor cannot be effaced by pressure on the artery above the sac, as in the first stage.

(c) The *bruit* is generally present, although it is heard with varying degrees of distinctness over the tumor, and also can be heard at a distance from the sac.

It will be observed that these symptoms, which were so marked and almost pathognomonic in the first stage, are of rather negative character in the second stage. There are, however, additional signs:

(d) *Pain*.—The pain is sharp and lancinating, like that of carcinoma, or aching or boring, like that of ulceration. It arises after the aneurysm has attained some size and makes pressure upon the nerves. Thus in popliteal aneurysm the pain is intense along the course of the popliteal nerve. The nerve is sometimes flattened out upon the sac. Pain may be at times an early symptom of aneurysm, but it is generally more pronounced later on in the course of the disease.

(e) *Œdema*.—This is produced by the pressure of the sac upon the veins. Œdema of the limb is constant after the tumor has attained a certain size. The œdema, if excessive, produces a great deal of discomfort to the patient, and may terminate in extensive ulceration and sloughing.

(f) *Gangrene* sometimes occurs late in the course of the disease, and generally follows the œdema, but may come suddenly as the result of an embolus.

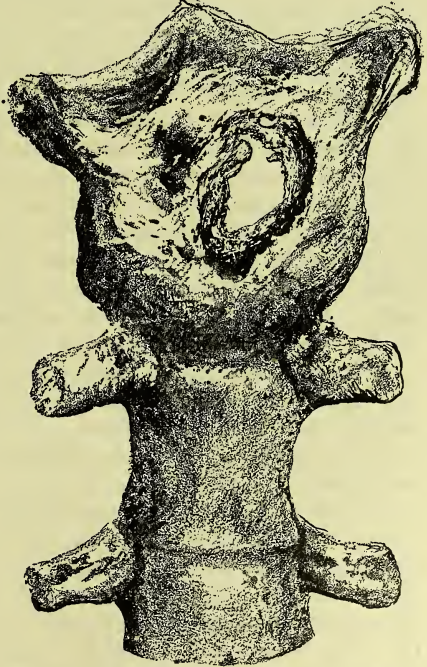
(g) *Pressure-effects* vary according to the parts pressed upon and the amount of pressure exercised by the tumor.

If the aneurysm presses upon bone, it produces a severe aching, boring, gnawing pain, and finally causes the absorption of the osseous tissue (Figs. 35 and 37); if upon glands, it destroys their function; if upon the trachea, respiration is rendered difficult, and there is an obstinate distressing metallic cough and altered voice produced by pressure upon the recurrent laryngeal nerve. This is termed the brassy cough of aneurysm. If the aneurysm presses upon the œsophagus or the thoracic duct, deglutition or nutrition is interfered with and the patient dies from inanition. If the pressure be on the phrenic nerve, hiccough often is produced; and if on the sympathetic nerve, marked capillary congestion.

Diagnosis of Aneurysm.—If the aneurysm has not consolidated, the symptoms which have been enumerated will enable the surgeon to establish a diagnosis. But it often happens that after consolidation of the aneurysm by fibrin many of the signs and symptoms become obscure and a diagnosis is rendered somewhat difficult. Again, certain other tumors under exceptional circumstances may present signs almost identical with those of an aneurysm.

In a case of consolidation the history of the disease, and occasionally the use of the hypodermatic syringe, are the only safe guides for the surgeon. In pulsating tumors which resemble aneurysm the diagnosis must be made with great care.

FIG. 37.



Absorption and Perforation of the Sternum from Pressure by an Aneurysm (original).

The different tumors with which a surgeon may confound an aneurysm are the pulsating encephaloid, the vascular soft sarcoma, erectile tumors of all kinds, pulsating tumors of bone, an abscess over an artery, and hematocele of the neck.

There are also tumors which are not, strictly speaking, pulsating which have led to error in diagnosis and treatment, such as lymphatic enlargement and cystic disease of the thyroid gland, and certain other diseases, as neuralgia and rheumatism, the pain in both of which has been mistaken for that of beginning aneurysm in the thoracic cavity.

Duration of Aneurysm.—An aneurysm may grow very rapidly, but this is rare. The growth, as a rule, is slow, and may extend over several years. The aneurysm is likely to grow as long as the cause is present. Its duration is influenced by the force of the circulation, its situation, the size of the mouth of the sac, the coagulating tendency of the blood, the nature of the surrounding parts, the condition of the sac, and the patient's habits and manner of living.

Treatment.—The surgeon must aim in his treatment to effect a cure by precisely those means which nature adopts. The essential conditions for success in any plan of treatment are obliteration of the cavity of the sac and occlusion of the afferent and efferent vessels.

There are several ways in which obliteration of the sac and the vessels can be accomplished, but often the best results will be obtained by a combination of various methods of treatment. In order to occlude the sac it is necessary to diminish the force of the circulation, thus causing coagulation of the blood in the aneurysmal sac. When this has been effected a cure may be expected.

The methods resorted to may be either *medical* or *surgical*.

The medical methods which have met with the greatest success in curing aneurysm are those suggested by Langenbeck and by Tufnell. *Langenbeck's method* consists in the hypodermatic injection of ergotin. This drug slows the action of the heart, and hence favors deposit of fibrin; it contracts the muscular fibers of the middle coat of the arteries leading into the sac, and produces increase of blood-pressure. All these are favorable to the deposition of fibrin and the consolidation of the aneurysm. Iodide of potassium has also been used in the medical treatment, largely upon the supposition that aneurysms are due to the effects of syphilis, but it probably acts as a heart depressant. Acetate of lead has been employed to equalize the circulation. Bromide of potassium has been used to relieve the cough and pain.

Tufnell's method is a modification of a plan of treatment originally suggested by Valsalva. It is especially applicable to internal aneurysms; but a brief description of it is proper here, as external aneurysm has been thus successfully treated, and as a list of the different methods of curing aneurysms would be incomplete without reference to this peculiar plan of treatment.

In 1875, Tufnell, an Irish physician, published his experience in what may be termed the *rest treatment* of aneurysm. Tufnell required his aneurysmal patients to assume the recumbent position in bed for several months. The object of the treatment was to reduce the watery elements of the blood and to increase its solid constituents. Rest, regimen, and remedial agents were the three means he employed. He showed that in the recumbent position the circulation was tranquillized and the action of the heart became regular and slow. He maintained that recumbency placed the same check upon the circulation in internal aneurysm that mechanical compression does in the treatment of external aneurysm. He demonstrated this proposition in the following way: A patient before assuming the recumbent position had a pulse of 96 a minute;

after a few days' lying supine in bed it fell to 66 a minute. Thus there was a difference of 30 beats a minute caused by position. Multiplying 30 beats by 60, the number of minutes in an hour, the result is 1800 beats an hour, and this multiplied by 24—the number of hours in a day—gives 43,200 beats per diem; that is to say, a patient suffering from aneurysm and occupying the recumbent position has his aneurysmal sac distended 43,200 times less frequently in a day than it would be if he remained in the standing position. Tufnell held that there was no remedial agent in the Pharmacopeia that would produce such an action upon the heart without injury or danger. Recumbency is the secret of cure, but it must be continued for three months. The diet was restricted to 10 ounces of solid and 6 ounces of fluid in the twenty-four hours. This reduction of nourishment diminished the action of the heart and increased the plasticity of the blood, and hence favored the consolidation of the aneurysm. Tufnell also directed certain remedial agents to be combined with rest, such as lactucarium to quiet the patient and induce sleep, and opium to soothe pain. Compound powder of jalap was used at intervals, to reduce the quantity of circulating fluid by withdrawing the serum from the blood. He gives an analysis of 10 cases treated by his method: 7 were cured, and 3 died during treatment. One of the successful cases was an aneurysm of the popliteal artery, cured in twelve days.

The surgical treatment of aneurysm may be subdivided into—1st, those methods which embrace some form of compression; 2d, those which embrace some form of surgical operation; 3d, those which may be classed as miscellaneous.

1. *Compression*.—The treatment of aneurysm by compression was employed over two hundred years ago, but only in cases of traumatic aneurysm. The manner of employing compression in the seventeenth century for the cure of aneurysm was essentially different from that employed at the present time, both in its principle and in its application.

The principle upon which surgeons based the treatment of traumatic aneurysm by compression in the seventeenth century was this: the compression was supposed to prevent the further dilatation of the aneurysm and to squeeze the blood out of the sac into the arteries, as water would be squeezed out of a sponge; the edges of the cut artery were thought to be thus brought into apposition and to become adherent, and the blood to pass through the restored artery as if nothing had happened. From this description it is evident that little was known of the nature or pathology of aneurysm. That the principle upon which the treatment was based was erroneous will be seen when we study the subject in the light which modern pathology has thrown upon it.

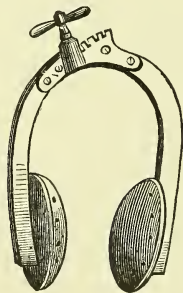
In the eighteenth century Heister was the first to propose to extend the plan of treatment of traumatic aneurysm by compression from the brachial artery, to which compression had been limited, to the popliteal artery, but he did not carry his plan into execution. It was reserved for Guattani, an Italian surgeon, in the year 1772 to treat the first case of popliteal aneurysm by compression. He applied compression directly upon the sac and also bandaged the entire limb, believing that the aneurysm was cured upon the same principle that has been mentioned. The cases treated by this means usually resulted fatally. By direct compression a circumscribed aneurysm was often transformed into a diffuse one; the sac became inflamed and suppurated; the limb became gangrenous, and half of the patients died. This was the state of affairs when, in 1785, John Hunter tied the femoral artery in Hunter's canal for the cure of a popliteal aneurysm, and announced a new principle, which changed all the opinions then held as to the way in which compression cured an aneurysm, and was followed by a complete revolution in practice.

Desault ligated the popliteal at some distance above the sac earlier in the same year, and a claim of priority has been based upon this fact. The Hunterian method is mentioned in this connection only to show the change produced by it in the treatment by compression. In another place it will be considered at length. The new principle involved was this: that it was necessary to arrest only partially, and not completely, the current of blood through the aneurysmal sac, which, from its own inherent elasticity, tends to diminish in size so soon as the full force of the heart's action is taken off: this contractility of the sac is an important element in the cure of circumscribed aneurysms by any method, and its absence in diffused as in traumatic aneurysms explains the failure of ligation and compression in the majority of such cases. Upon this principle and after Hunter's time compression was employed above the aneurysm, instead of, as always before, directly over it, and with greatly improved results. When this method is employed, the cessation of pulsation in the sac after the compression is relaxed, the absence of the thrill and bruit, together with the fact that the collateral circulation is fully established, indicate that the aneurysm is cured.

The enlargement and pulsation in the collateral vessels do not take place until the aneurysmal sac is obliterated by the deposition of fibrin; therefore the establishment of the collateral circulation is in itself a reason for supposing that the aneurysm is cured. It is through this collateral circulation that the extremity is supplied with blood. This prevents gangrene from attacking the parts below the sac. The collateral vessels soon develop into vessels of important size. The pain which has been recorded in the cases in which spontaneous cure was effected, as well as in those cases in which compression accomplished a cure, has been said to have been due to the sudden enlargement of the anastomosing vessels consequent upon the complete solidification of the sac, and may thus occasionally be considered a favorable symptom.

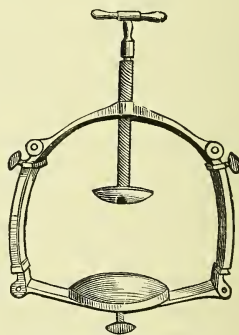
Instrumental compression is carried out by the employment of one of the many different varieties of tourniquets or compressors. Whatever instrument is employed for the purpose (Figs. 38, 39), only the artery must be compressed,

FIG. 38.



Signorini's Tourniquet.

FIG. 39.



Skey's Tourniquet.

and at no time during the period in which the instrument is applied must the pressure be greatly relaxed. A piece of chamois-skin should be placed over the artery, so that the pressure of the instrument shall not excoriate the skin.

The time required to cure an aneurysm by compression varies from one to several days. The instrument must be kept on the artery until the pulsation in the sac has ceased, and then the amount of pressure during the following twenty-four hours can be lessened gradually. This gradual diminu-

tion of the amount of compression after pulsation has ceased is necessary, because otherwise the current of blood might disintegrate the clot in the sac before it is firm and solid.

Digital pressure was first employed by Jonathan Knight of New Haven, Conn., in 1848. In the same year Dr. Willard Parker and Dr. James R. Wood of New York City each cured an aneurysm by digital pressure. The pressure is maintained by relays of students or assistants for from one to two days, and this method is preferred by many surgeons to all other methods of compression. The same principle of treatment has been carried out by the use of instrumental pressure instead of digital, with fairly satisfactory success. A bag of shot, suspended over the bed by means of elastic tubing, has been used to secure uniform pressure upon the artery above the sac.

Flexion of the joint was brought to the attention of the profession in 1858 by Mr. Hart of England. The principles involved in this method are similar to those involved in compression. The plan is usually applicable only to aneurysm at the bend of the elbow and in the ham, although it has been successfully employed also in aneurysm of the external iliac. The leg is flexed upon the thigh and the thigh upon the pelvis; or the forearm is flexed upon the arm. The entire extremity is bandaged before flexion. Flexion causes compression directly upon the tumor itself, and also impedes the circulation through the sac, and probably dislodges a small clot which closes the mouth of the sac. This method is not suitable where the aneurysm is large, because of the liability of the sac to rupture, and is contraindicated if there is much oedema of the leg or inflammation of the sac. In ordinary cases it may be tried, since no harm follows if the treatment is unsuccessful. It is especially applicable to cases in which the tumor is small, the sac not inflamed, and the joint not involved.

Rapid Cure by Esmarch's Elastic Bandage.—In 1864, Murray, an English surgeon, anesthetized a patient suffering from an aneurysm of the abdominal aorta, and applied an instrument which completely checked the flow of blood through the arteries leading into the sac. The treatment resulted in cure. In this the so-called "rapid method" the object was to produce complete stagnation of a mass of blood in the sac until it coagulated. In 1875, Reid of the British navy treated aneurysms successfully by the rapid method by employing Esmarch's elastic bandage. The formation of a blood-clot in the sac is essential in order to effect the cure of an aneurysm by this method. That variety of blood-clot which is formed while blood is at rest is required (the red blood-clot), and not the one that is formed while blood is in motion (the fibrinous or white blood-clot). In order to accomplish the formation of a blood-clot in contradistinction to the formation of fibrin there must be a stasis of blood in the sac, followed by coagulation of the blood. This clot does not finally undergo organization, but contracts. Its chief object is to aid in the formation of a thrombus in the afferent and efferent vessels leading into and out of the aneurysm. Not all aneurysms are amenable to this treatment. There should be no vascular degeneration except in the aneurysm, likewise no renal disease, and the sac itself should be free from inflammation. The administration of the iodides and restricted albuminous diet are useful adjuvants.

The patient should have a hypodermatic injection of morphine before taking ether, and just enough of the anesthetic should be administered to keep him quiet and free from pain during the treatment. The elastic bandage should be firmly applied from below upward till the aneurysmal sac is reached, then carried very lightly over the sac itself, and reapplied firmly above it, so as to confine a quantity of fluid blood in the sac. The patient must be kept under ether for an hour or an hour and a half. A tourniquet should be adjusted above the aneurysm,

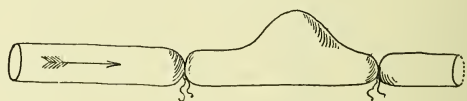
to moderate the blood-current and prevent its disturbing and washing out the clot in the sac and the thrombi in the afferent and efferent arteries. The tourniquet can be kept on the limb for from sixteen to twenty-four hours after the removal of the bandage, and must be unscrewed gradually, so as to restore the blood-supply in proper quantity. The two dangers to be guarded against are, on the one hand, washing out the clot before it is solid, and on the other the production of gangrene of the limb by too long-continued pressure. The effect of the arrest of the blood-supply must be carefully watched from hour to hour as the tourniquet is gradually unscrewed. The collateral circulation will soon be established. The risks of the sudden rise and fall of arterial tension, the compression of nerves, the rupture of the sac, the development of kidney disease, and the possibility of gangrene, are all to be considered. These dangers also accompany other methods, but perhaps are as little likely to occur after this plan as after any other operative interference or after compression applied in any one of the many ways already described.

The treatment of aneurysm by any of the different methods of compression is not without difficulties. If the instrument is not adapted to the exigencies of the case, if the patient is irritable and cannot bear pain well, or if the aneurysm is unfavorably situated for the application of an instrument or of digital compression, there will arise difficulties which will discourage the patient as well as the surgeon. If, however, after even weeks of perseverance no good has been accomplished, both patient and surgeon should remember that no great risks have been incurred involving the life of the patient, and no conditions absolutely contraindicating a trial of operative measures have been produced. Few cases in which the treatment by compression in some form has been faithfully persevered in for a long time have been unattended with improvement.

2. *Those methods which embrace some form of surgical operation.*

The Old Operation of Antyllus (Fig. 40).—The earliest recorded treatment of aneurysm is that devised by Antyllus, who lived in the fourth century. At that time it was employed only in cases of small traumatic aneurysms situated at the bend of the elbow. The method was simple, and was described by him as follows: an incision was made along the inner aspect of the arm over the brachial artery. The vessel, having been exposed, was tied on each side of the aneurysm. The aneurysm was then laid open and the contents of the sac were turned out.

FIG. 40.



Old Operation of Antyllus for Aneurysm (original).

This operation was performed for several hundred years, and it was not until the eighteenth century that any other was practised even in idiopathic aneurysm. The great mortality in this form of aneurysm was due to the fact that the artery was tied immediately above and below the sac, *where the vessel was unsound*, and hence secondary hemorrhage and exhaustive suppuration, with ankylosis of the joint, followed. The principle involved in the old operation, with certain omissions and modifications, is still applicable in axillary and gluteal aneurysms and in traumatic aneurysm at the bend of the elbow.

Anel's Operation (Fig. 41).—Anel in the year 1710 devised and performed a new operation for the cure of aneurysm. He did not open the sac as in the old operation, or tie the artery above and below the sac, or

stuff the wound with myrrh. He thought that the tumor would collapse if the main artery leading into it were tied near the aneurysm. He was successful, and thenceforward the treatment of aneurysm rested upon a scientific basis.

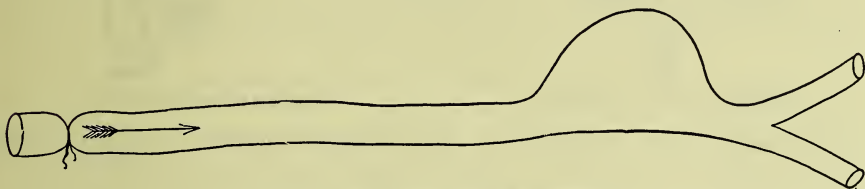
Anel, however, did not apprehend correctly the principle which his operation involved. He thought the tumor simply collapsed, and it was not until some years afterward that the true principle underlying this operation of ligaturing the artery upon the cardiac side of the aneurysm was brought to light—not indeed until John Hunter, in 1785, on account of the many failures in the treatment of aneurysm by compression, was led to

FIG. 41.



Anel's Operation for Aneurysm (original)

FIG. 42.



Hunter's Operation for Aneurysm (original).

investigate the subject from a pathological point of view, and devised the operation for its cure which has made his name immortal.

Hunterian Operation (Fig. 42).—Hunter demonstrated by experiments upon dogs that weakness alone was not the cause of dilatation of an artery, but that there must be some previous disease of the coats of the artery itself before the force of the circulation would develop an aneurysm. He proved that the disease was not confined to the artery at the seat of enlargement only, but extended some distance from the sac; and this fact, he thought, explained the cause of failure of treatment by Anel's method, in which the artery was tied at a point where it was diseased, permitting the ligature to come away too soon and secondary hemorrhage to occur.

Hunter proposed, therefore, to tie the artery at a distance from the sac, at a point where the vessel was healthy, and thus diminish the risk of secondary hemorrhage. He thought, moreover, that if the force of the circulation were taken off from the aneurysmal sac the disease would be arrested, and the sac and its contents would be absorbed. The conclusion which he drew from his observations was that simply taking off the force of the circulation from the aneurysmal artery is sufficient to effect a cure of the disease, or at least to put a stop to its progress, and enable the processes of nature to restore the parts to a normal state.

The *conditions* under which the Hunterian operation is indicated are as follows: the aneurysm must be of moderate size; it must be of slow growth; and the sac must not be inflamed. Slight œdema would not contraindicate the operation. Gangrene would preclude all operations except amputation.

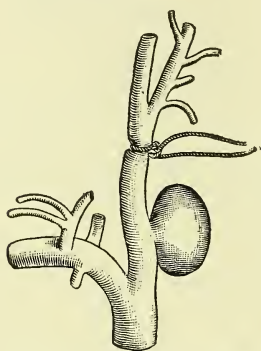
The *accidents* following the Hunterian operation are—secondary hemorrhage, return of pulsation in the sac, inflammation and suppuration of the sac, gangrene of the extremity, pyæmia, and septicæmia.

Brasdor's Operation (Fig. 43) consists in ligating the artery upon the distal side of the sac, so that the circulation upon that side is completely

arrested. The cases in which this method can be adopted are aneurysms of the carotid artery, of the external iliac, etc.

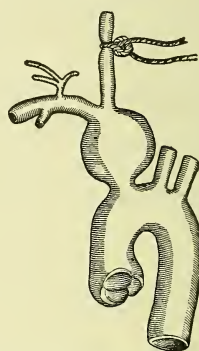
Wardrop's Operation (Fig. 44) consists in tying the artery or one of its branches upon the distal side of the sac, the principle on which it is founded

FIG. 43.



Brasdor's Operation (Holmes).

FIG. 44.



Wardrop's Operation (Holmes).

being the same as that in Brasdor's. It arrests the circulation to a great extent, but still permits the escape of blood through one or more branches. It is applicable only to aneurysm of the innominate artery or of the arch of the aorta. The carotid or the subclavian alone, or both of these vessels, may be tied, and the two operations may be either simultaneous or consecutive. The branches of the subclavian between the ligature and the aneurysm keep up a diminished circulation.

Before dismissing the subject of ligation, the *advantages of compression over ligation* will be considered. These advantages are that—

1st. Compression effects a cure in accordance with nature's laws. The sac after compression consolidates just as in spontaneous cure; only the sac itself is consolidated, and not all the arteries up to the point where pressure is made, as is the case after ligation.

2d. Compression is less dangerous than ligation. If any danger arises during compression, the treatment can be discontinued and then resumed. Not so with ligation, for then the patient may be in great danger for many days after operation.

3d. Compression is more likely to be attended with success than ligation. There are not so apt to be complications, such as secondary hemorrhage, sloughing of the sac, phlebitis, gangrene, or pyemia, occurring during compression and preventing a cure.

4th. Compression is more likely to be permanent than ligation. A second aneurysm has been known to form after ligation, and also suppuration to be set up in the sac; neither of these is likely to occur after compression, though both are possible.

3. *Those methods which may be classed as miscellaneous.*

Introduction of Foreign Bodies into the Sac.—This method consists in puncturing the sac with a canula and introducing through it several yards of fine wire. Moore, in 1864, passed twenty-six yards of fine wire into an aneurysmal sac. The patient died of pericarditis and inflammation of the sac. Recently, Loreta introduced some silvered copper wire into the sac of an abdominal aneurysm. A firm clot was formed, but the patient died two months after the operation. Besides wire, other materials have been employed, such

as catgut, silk, and horse-hair. Whatever material is used, the operation is attended with great danger.

Manipulation.—This method was introduced by Fergusson in 1852. The object is to displace some of the fibrin in the sac by manipulating the aneurysm, and thus to block up the artery upon the distal side of the sac. The aneurysm is first emptied by making pressure on the afferent artery, and then the sac is kneaded and rubbed in order to detach a small embolus which shall be swept into the efferent artery and thus obstruct it mechanically. The operation has fallen into disuse, owing to the fact that emboli were carried to the brain, causing aphasia, hemiplegia, and even death.

Galvano-puncture is a method suggested by Phillips in 1829. The object is to produce coagulation of blood in the sac without the intervention of any foreign body. A galvanic current is passed through an insulated needle which is brought in contact with the point of another insulated needle introduced into the sac about an inch from the point of entrance of the first needle. Suppuration of the sac, hemorrhage through the punctures in the sac-wall, and embolism are among the dangers that attend this method.

Acupuncture by means of very fine gilded needles has been employed. The needles are introduced into the sac so as to cross each other, and the blood coagulates around them. The needles are left in the sac several days, and then are withdrawn.

Extirpation of the aneurysm was first practised by Philagrius of Macedon in the fourth century. A most formidable operation in those days, it has been revived of late with marked success by the aid of anesthetics and with the certainty of aseptic healing.

The technique of the operation consists of a free incision over the site of the aneurysm, so as fully to expose the continuity of the vessel. Two ligatures are now applied to the artery upon the proximal side of the sac, a short distance from it, and the vessel divided between the ligatures. The same procedure is to be followed upon the distal side of the aneurysm after carefully dissecting out the entire sac with its contents and severing them from their connections.

The special advantages of extirpation of the aneurysmal sac over proximal ligature, compression, or any other method are the removal of the dangers of emboli which might cause gangrene, the absolute permanency of the cure, the absence of secondary hemorrhage, the freedom from sepsis, and, finally, the lessened mortality—advantages not secured by the other methods.

The mortality of proximal ligature has been placed by Delbel at 18 per cent., that of total extirpation of the sac at 11 per cent.; the occurrence of gangrene after proximal ligature about 8 per cent., after extirpation only 3 per cent. Ransohoff collected twenty-eight extirpations of major aneurysms of the extremities without a single death.

Extirpation of the aneurysm is especially indicated in the traumatic variety, notably those situated upon the extremities. This operation is also indicated when the sac has ruptured or when other methods have failed to cure the disease.

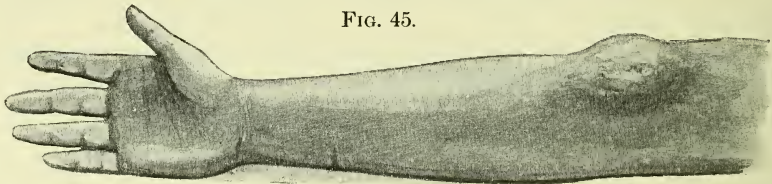
Amputation is required in certain aneurysms. This is necessary if an aneurysm has burst, if hemorrhages are frequent, if a joint is involved, if caries of bone has ensued, or if gangrene of the extremity has occurred.

Coagulating Injections.—In this method injections of certain drugs are made into the sac with a view of causing coagulation of the blood. Such injections should not be employed in aneurysms situated in the neck, because emboli may be transmitted to the brain and cause instant death. In aneurysms

involving the extremities, injections of Monsel's solution of iron, tannin, acetate of lead, and other drugs have been employed. Whatever injection is used, pressure should be made for some little time upon both the afferent and the efferent arteries, to prevent emboli from being swept into the circulation.

Macewen's Method, which consists in inducing the formation of white thrombi within the sac, is a recent plan of treatment which will sometimes be useful. The formation of these thrombi is accomplished by irritating the lining membrane of the aneurysmal sac in such a way as "to induce infiltration of the parietes with leucocytes, and a segregation of them from the blood-stream at the point of irritation." The amount of irritation should be sufficient to cause merely a reparative exudation, as any irritation beyond this stage would result in softening of the sac-wall, which in turn might lead to rupture. The irritation should be evenly applied within the whole surface of the sac, or at least from many foci distributed uniformly throughout its interior. The technique of the operation is as follows. The skin over the sac having been made aseptic, a long, strong cylindrical needle, also rendered aseptic, is introduced into the interior of the sac. The point of the needle should be allowed to impinge upon the opposite wall of the sac, so as to irritate the lining membrane, or else the needle should be held lightly in this position for a few moments, so as to allow the impulse of the blood-current to play on it. It should be shifted to other parts of the sac at intervals of ten minutes, until the whole sac has been uniformly irritated. The simultaneous use of a second or even a third needle at distant points may be necessary. The time required to irritate the whole sac varies from a few hours to forty-eight hours. While the needle is left *in situ* in the sac, an antiseptic gauze dressing should be applied to the surrounding region. It may be necessary to repeat the operation from time to time for weeks or even for months. This method should not be employed

FIG. 45.

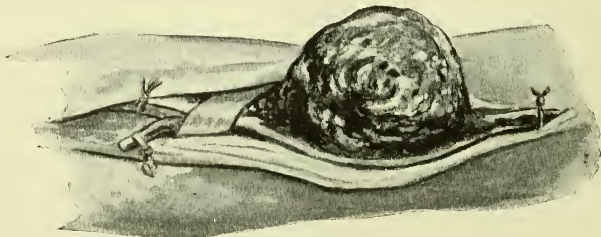


Diffuse Traumatic Aneurysm of the Brachial Artery.

if there is any inflammation in the walls of the sac, any superficial ulceration, or any erysipelatous induration.

TRAUMATIC ANEURYSM (Figs. 45, 46).—This variety of aneurysm differs

FIG. 46.



Traumatic Aneurysm laid open and Vessels tied.

from all the others in the manner of its causation, as well as in the condition of the parts involved. In all varieties of aneurysm except the traumatic, the

disease is situated in the coats of the arteries. In the traumatic variety the lesion, as its name implies, is the result of a direct injury to the vessel, and an arterial hematoma results.

This form of aneurysm is caused by a stab or gunshot wound, or by the giving way of cicatricial tissue which has imperfectly healed a wound of an artery. The blood escapes from the injured artery, and extravasates throughout the tissues until by mechanical pressure the hemorrhage is arrested. The pressure of so much extravasated blood in the tissues with superadded infection by pyogenic microbes causes an inflammation of the parts, and if not treated an abscess may possibly form, the opening of which may result in an alarming hemorrhage.

The **symptoms** of traumatic aneurysm depend upon its situation and the size of the vessel wounded. The presence of a tumor suddenly developed after an injury to a vessel, accompanied by severe pain and tension, with pulsation and bruit, and absence of pulsation beyond the aneurysm, is indicative of this form of aneurysm. In addition to these signs, a certain redness of the skin from inflammatory tension soon appears, and unless this tension is relieved sloughing is apt to occur, and in some cases even gangrene of an extremity.

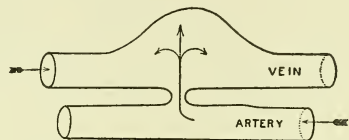
Traumatic aneurysm must not be mistaken for an abscess, which it often resembles. The diagnosis between the two conditions can be made by the history, by the symptoms, and, if necessary, by introducing a hypodermatic needle. Fluid blood indicates an aneurysm, while pus suggests an abscess. The fact that an abscess may be the direct result of a traumatic aneurysm must not be overlooked.

The **treatment** of traumatic aneurysm is based upon the same principles that would guide the surgeon in the management of a primary wound of an artery. If in an extremity, an Esmarch elastic bandage should be applied and the tumor cut down upon until the injured artery is found. The vessel should be completely divided and the two ends securely ligatured. The wound should then be thoroughly disinfected and dressed antiseptically, in order to secure healing by primary intention. In cases in which an elastic bandage cannot be employed—*e. g.* in the neck—a serious difficulty arises. When this is the case the surgeon should carefully dissect down to the aneurysm, and make an opening sufficiently large to admit his finger into the tumor, by which he should seek for the opening into the artery on the proximal side of the aneurysm, in order to arrest the hemorrhage by pressure. The finger may be guided to the opening in the vessel by feeling the current of warm arterial blood impinge upon it. When the opening has been occluded, the surgeon can enlarge the wound so that he may be enabled quickly to turn out the fluid blood and the coagula in the false sac. The vessel is then tied between the finger and the heart by means of a curved aneurysm needle armed with a catgut or silk ligature. The artery on the distal side of the aneurysm must then be secured by a similar ligature, otherwise, if the collateral circulation has been established before the operation is done, very troublesome hemorrhage would arise from this point. If the vessel is in an extremity, is very large, and the traumatic aneurysm is situated near the trunk, an amputation may be necessary, especially if the injury to the vessel has been caused by a gunshot wound.

AN ANEURYSMAL VARIX is a communication between an artery and a vein without the intervention of a sac. It may result from unskilful venesection, from the thrust of a sharp instrument, from a pistol-shot wound, etc. If an artery and a vein have been wounded by venesection, for example, so that

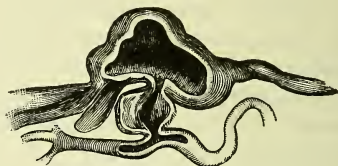
a communication is established between them, an aneurysmal varix is formed. When this accident happens, a pad or compress is laid firmly over the wounded part, so as to arrest the hemorrhage. The walls of the artery and vein in consequence of the slight inflammatory action become adherent to each other at

FIG. 47.



Plan of an Aneurysmal Varix (original).

FIG. 48.



Varicose Aneurysm (Spence).

the margins of the wound, but the wound itself does not heal, since at each pulsation of the heart a stream of arterial blood is thrown through the opening into the vein. The blood thus projected from the artery into the vein finally dilates the latter (Fig. 47). The blood as it enters the vein comes in contact with the opposing venous stream, and so produces a whizzing sound which is pathognomonic of an aneurysmal varix. Once heard, the sound will never be mistaken. It has been compared to many noises. One of the best comparisons (which is as ludicrous as it is forcible) was suggested by the late Mr. Spence—viz., the noise which a bluebottle fly imprisoned in a thin paper bag makes in its efforts to regain its freedom. Valentine Mott compared the noise to the purring of a kitten.

Aneurysmal varix may exist for years and give rise to no serious disturbance. There is some alteration in the coats of the vein and of the artery, but none that would offer resistance to the flow of blood, as is the case in an aneurysm. There is dilatation of the vein, but not enough to cause ulceration or rupture. The veins beyond the varix are always more or less dilated and enlarged.

Treatment.—In some cases of aneurysmal varix no operative interference is called for. All that is then necessary is to apply an elastic bandage, which prevents further enlargement. The disease, however, sometimes extends and occasions pain and disturbance in the circulation. In these cases pressure by means of a firm compress should be made upon the artery above and upon the vein below, and also directly over the aneurysmal varix. If this does not cure the disease after a fair trial, the tumor should be treated by operation. The aneurysm should be exposed by dissection, a ligature placed above and below the opening in both the artery and the vein, and the aneurysm extirpated. In aneurysmal varix of the carotid and the internal jugular and of the common femoral vessels operative interference should be undertaken only when the reasons are very urgent.

Varicose Aneurysm.—A varicose aneurysm is similar to an aneurysmal varix, since in both there is a communication between an artery and a vein; but in the varicose aneurysm there is a sac between the artery and the vein. The arterial blood is projected into this sac, and from the sac into the accompanying vein (Fig. 48).

Both aneurysmal varix and varicose aneurysm are often called **arterio-venous aneurysm**.

Varicose aneurysm, like aneurysmal varix, is the result of a wound both of the artery and of the vein; but in the case of varicose aneurysm if not treated, or if the compress which was placed over the wound at the time of the accident was not firm enough, blood will have extravasated between the walls of

the artery and the vein and separated the two vessels. Inflammatory lymph has then been deposited around this space, and thus a false aneurysm has been formed, communicating with both vessels; its sac consists of condensed effused lymph. This intervening sac which comes from the false aneurysm must not be confounded with an ordinary false aneurysm the result of a wounded artery alone. In the ordinary false aneurysm there is no communication with a vein.

On account of the slight arterial pressure exerted by the force of the circulation upon the walls of the sac of a varicose aneurysm, the sac is not subject to great enlargement. In an ordinary aneurysm the force of the blood-current impinges directly upon the aneurysmal sac; in a varicose aneurysm the blood-current finds its way through the aperture into the vein, and thus its force is distributed into the vein instead of impinging directly upon the sac. While, then, enlargement of the sac is not common, yet in view of the liability of the sac to slough, and the danger of gangrene of the limb or of the false aneurysm's becoming diffuse, the indication for surgical interference is plain.

The **symptoms** are nearly the same as in aneurysmal varix, with the exception of the presence of a sac, which sometimes can be made out by palpation, and over which can be heard a soft bruit.

Treatment.—Varicose aneurysm must not be left to itself, for it will finally ulcerate and become diffuse. Compression is not suitable, as the already dilated and varicose veins would become greatly enlarged, and finally cause much œdema and expose the patient to the risk of gangrene. In most cases of varicose aneurysm, especially if the aneurysm is small, ligature of both vessels above and below the disease, followed by extirpation, is a well-recognized operation. In cases of varicose aneurysm situated in the neck or in the anterior femoral region, this procedure would be attended with great danger. The Hunterian operation of tying the femoral artery above the sac in healthy tissue has been tried in two cases, and death followed in both instances. The reason for the failure of ligation of the artery by Hunter's method is that the conditions in an ordinary aneurysm and in the varicose aneurysm are different. In the ordinary aneurysm the ligation of the artery causes deposition of fibrin in the sac on account of the lessened amount of blood slowly entering the sac; in the varicose aneurysm the communication through the sac with the vein offers an unimpeded passage of the blood into the venous circulation, and the return venous circulation through the sac prevents coagulation, for blood in motion will not coagulate.

The late Mr. Spence of Edinburgh devised and carried into successful execution an operation for varicose aneurysm which meets the theoretical as well as the practical indications. To use his own words, he cuts down upon the artery above the sac, and then below the sac, but does not open the sac or disturb the vein. The application of two ligatures to the artery at the places mentioned removes the disturbing influence in the retrograde current of arterial blood, and thus permits the blood in the sac to remain unagitated by the meeting of two currents and to coagulate, causing the consolidation of the tumor.

ANEURYSMS OF SPECIAL ARTERIES.

Carotid aneurysm is usually situated at the point where the artery bifurcates upon either side of the neck. Upon the right side the aneurysm may develop at the origin of the vessel. It begins with the appearance of a small tumor, which may grow slowly or very rapidly. The symptoms of carotid aneurysm are those common to any other aneurysm, with, in addition, dyspnea, difficult deglutition, vertigo, hoarseness, brassy cough, and ringing in the ears.

The **diagnosis** of carotid aneurysm is often attended with great difficulty. The affections for which this disease may be mistaken have already been considered under the differential diagnosis of Aneurysm.

The **treatment** of carotid aneurysm is best carried out by means of a ligature upon the proximal side of the sac if there is sufficient room, otherwise upon the distal side. Among the accidents that may follow ligature of the carotid may be mentioned embolism, cerebral softening, hemiplegia, syncope, secondary hemorrhage, and suppuration of the sac.

If it becomes necessary to ligate both carotid arteries, they should not be tied simultaneously, as this double operation has been attended by fatal coma.

SUBCLAVIAN ANEURYSM is found most frequently in the third portion of the vessel. The tumor appears under the clavicular origin of the sternocleido-mastoid muscle, the direction of its long axis corresponding with the direction of the artery. Besides all the symptoms common to aneurysm in general, subclavian aneurysm has some special signs. Among these may be mentioned pain along the nerves belonging to the brachial plexus, if on the right side a brassy cough from irritation of the recurrent laryngeal nerve, a varicose condition of the jugular veins, delayed radial pulsation, and finally œdema of the arm and hand. These symptoms increase in severity as the tumor enlarges.

The **diagnosis** of a subclavian aneurysm in the third portion of the artery from one involving the lower portion of the carotid or the subclavian in its first portion, or even the innominate, must be made. The chief diagnostic points of subclavian aneurysm in its third portion are the simultaneous pulsation of the carotid arteries and the delayed radial pulsation upon the affected side. The simultaneous delay of the carotid and radial pulsations of the right side indicates an aneurysm of the innominate artery instead of the third portion of the subclavian.

Treatment.—If the aneurysm is small and limited to the third portion, digital pressure upon the proximal side of the subclavian, although difficult for anatomical reasons, may be attempted in conjunction with constitutional treatment. Pressure directly upon the sac has been successful in a few cases. If compression fails, the artery should be ligated upon the distal side, since proximal ligation has rarely proved effectual. It may be necessary, where other means have failed, to ligate the artery on the proximal side as a preparatory step, and then immediately to amputate at the shoulder-joint.

AXILLARY ANEURYSM may be idiopathic or traumatic. The idiopathic variety may be developed by the stretching of the vessel in reducing an old dislocation or by a too free movement of the shoulder-joint, or by atheroma of the vessel. This variety of aneurysm grows very rapidly, owing to the laxity of the surrounding tissues, which permits it to dilate without early mechanical obstruction. It quickly attains a large size, and the situation of the sac renders it especially prone to inflammation. The pressure of the aneurysm soon causes venous obstruction, and œdema of the forearm ensues. The pain is often very severe, on account of the irritation of the brachial plexus. The pulse at the wrist corresponding to the side of the aneurysm is delayed when compared with that of the opposite side. If the sac continues to grow, the shoulder-joint is invaded, the ribs are eroded, and the corresponding lung is compressed. The movement of the arm is soon interfered with, and ankylosis of the shoulder follows. This variety of aneurysm may cause a dry pleurisy or a hyperplastic pneumonia.

The **treatment** consists in applying digital or instrumental compression to the third portion of the subclavian artery, and, in the event of failure, in tying

this portion of the vessel. The application of an elastic bandage to the arm, combined with pressure upon the proximal side of the sac, can also be tried. Other methods of treatment in this form of aneurysm are fraught with danger, and must not be undertaken without deliberate consideration.

In the traumatic variety of axillary aneurysm the injury may be produced by a stab or gunshot wound, or even, as has been said above, by external violence in attempting to reduce an old dislocation. In the treatment of traumatic aneurysm Mr. Syme has suggested a modification of the old operation of Antyllus. The subclavian is compressed firmly in its third portion, and the axillary sac is then opened, the coagula turned out, the wound found, the artery completely divided, and both ends ligated.

BRACHIAL ANEURYSM may be situated either along the course of the artery or at the bend of the elbow. The most frequent variety of aneurysm is the traumatic; but aneurysmal varix, and also varicose aneurysm, are found at the bend of the elbow as a result of unskilful venesection. For the treatment of these varieties of aneurysm see pp. 225-245.

In idiopathic aneurysm of the brachial artery compression or the modified operation of Antyllus or the Hunterian operation may be employed. In rare cases gangrene of the forearm may result from an aneurysm in this situation. This condition calls for amputation.

ILIAC ANEURYSM may involve the common trunk of the vessel, the internal or the external iliac artery, or their branches. In aneurysm of the *common iliac* artery the treatment consists in compression upon the cardiac side of the aneurysm. The pressure should be made as much as possible over the artery, and not over the sac. The results of ligation of the common iliac for aneurysm show a mortality of nearly 75 per cent.

The *internal* iliac artery is seldom the seat of idiopathic aneurysm. The *sciatic* and *gluteal* branches have, however, been the seats of aneurysm both of the traumatic and the idiopathic variety. If the aneurysm is idiopathic, the treatment should consist in proximal compression, and, if this fails, in the injection of remedies with a view to coagulating the blood. Recently, ligation of the vessel by a median laparotomy has been employed.

If the gluteal or sciatic aneurysm is traumatic, compression must be made above upon the main artery, the sac be laid open, the clots turned out, and the vessel tied above and below the wound.

The *external* iliac artery is often the seat of idiopathic as well as of traumatic aneurysm. In the idiopathic variety the method by compression should be first employed, and if this fails the ligature of the vessel above the sac is indicated. The vessel can be reached by a median laparotomy. If the aneurysm is of the traumatic variety, the modified operation of Antyllus is indicated.

FEMORAL ANEURYSM may be traumatic or idiopathic. From the exposed situation of the femoral artery, false aneurysms are of frequent occurrence. The treatment should consist in the application of a tourniquet to the artery as it passes over the brim of the pelvis, incision of the sac, and ligation of both ends of the divided artery. If the aneurysm is idiopathic, compression above the sac should be first tried, and in the event of failure the Hunterian operation should be employed.

POPLITEAL ANEURYSMS are usually idiopathic, but occasionally the traumatic variety is seen. The latter should be treated according to the rules given for the management of this form of aneurysm situated in any other part of the body. The idiopathic variety can be treated by the flexion method, by the Hunterian method, by proximal compression, or by the elastic bandage.

SECTION IV.—INJURIES OF THE BLOOD-VESSELS.

HEMORRHAGE is invariably present when a vessel is wounded. The blood may escape through the broken skin, or may extravasate beneath the skin and form a hematoma. The occurrence of severe hemorrhage is always attended with great danger to life, and the larger the caliber of the wounded vessel the greater the immediate danger. There is no other emergency which the surgeon is called upon to meet that requires so much judgment and presence of mind as the proper management of alarming hemorrhage.

There are four varieties of hemorrhage:

1. **ARTERIAL HEMORRHAGE**, characterized by bright-red blood spurting out in jets synchronously with the action of the heart. The bright-red color is due to the presence of oxygen in the blood. Arterial blood may be deprived of its characteristic color when the oxygen is greatly diminished and carbonic acid gas is present in excess, as in profound narcosis or when an operation is undertaken to avert death from apnea. During an operation, therefore, the surgeon should always look to the anesthetic if the blood from the wound becomes dark-colored.

2. **VENOUS HEMORRHAGE**, characterized by the blood flowing in an uninterrupted stream and by its dark color. The steady flow of the blood from the veins is due to the fact that the intermittent cardiac impulse is lost. For the same reason blood from the distal end of a wounded artery also flows in a steady stream. The dark color is caused by the non-oxygenation of the blood and by the presence of carbonic acid gas. The walls of the veins collapse, with the exception of the veins of the liver; the portal system, however, is seldom taken into account by the surgeon.

3. **CAPILLARY HEMORRHAGE**, characterized by its constant oozing on the one hand, and by its spontaneous arrest on the other. This variety of hemorrhage is alarming in exceptional cases only, but its persistence often makes it a troublesome variety to treat. The capillaries in the mucous membranes bleed more profusely than those situated in the integument. This is due to the fact that in the former the capillaries are larger and more abundant. Hemorrhage from capillaries situated in the skin usually ceases owing to the contraction of the wound.

4. **PARENCHYMATOUS HEMORRHAGE**, characterized by absence of the features which distinguish the other three varieties, and also by the fact that it is found where there is a peculiar anatomical arrangement of the blood-vessels, or among diseased tissues, as when the main vein is thrombosed. This variety of hemorrhage is seen in those organs or parts of the body where the small arteries empty into small veins without the intervention of a capillary system. Such an arrangement is found in the corpora cavernosa and in the erectile tissue of the female genitalia, as well as in the spleen.

Hemorrhage may be divided upon another basis than an anatomical one—viz. a clinical one. It may be termed—I. Primary; II. Intermediary; III. Secondary.

I. *Primary hemorrhage* occurs immediately after the wound in the vessel. The characteristics of a primary hemorrhage vary according as it is arterial, venous, or capillary, as above described.

II. *Intermediary or reactionary or consecutive hemorrhage* occurs shortly after an injury to a vessel or after a surgical operation, during what is termed the period of reaction. This variety of hemorrhage usually takes place within twenty-four hours, and is caused by a ligature's coming away, or by the action

of the heart in driving out coagula from the divided end of a vessel, or by some movement of the wounded part.

III. *Secondary hemorrhage* occurs after twenty-four hours and before organization of the thrombus and cicatrization of the wound, and most frequently between the fifth and tenth days. It usually occurs during suppuration, and is caused by disease of the walls of the vessel, by sloughing of the wound, by ulceration of the vessel, by sepsis, or by the too rapid absorption of a catgut ligature. Secondary hemorrhage is often seen in gunshot injuries and in wounds where there have been extensive contusion and sloughing.

The **constitutional symptoms of hemorrhage** are rapid, feeble pulse; subnormal temperature; frequent and irregular respiration; convulsive movements; lividity of the lips and blueness of the finger-nails; dilatation of the *alæ nasi*; nausea and vomiting; pale face and pallid mucous surfaces; great dyspnea; profuse perspiration; muttering delirium; tinnitus aurium; syncope; collapse; disturbances of sight and hearing; unconsciousness.

The symptoms just enumerated are present to a greater or lesser degree according to the amount of blood lost, the size of the vessel injured, and the general condition and the age of the patient. Infants and children do not tolerate the loss of blood well, but they recuperate rapidly. Aged people likewise are seriously affected by the loss of blood, and, unlike children, do not rally quickly. Adults in health endure well the loss of blood, and women during parturition tolerate hemorrhages which under other circumstances would prove rapidly fatal.

After hemorrhage has been arrested and the patient has rallied, the symptoms denoting the existence of hemorrhage change and a slight febrile disturbance follows. To this condition the term "hemorrhagic fever" has been applied. The elevation of temperature is due to the nervous irritation consequent upon the hemorrhage and to the absorption of the "fibrin ferment," as after operation. (See p. 35.) The pulse is accelerated and often irregular, and its wave is apparently more distinct than normal, owing to the relaxation of the coats of the vessel due to the absence of the natural stimulus of the blood.

The patient is in an asthenic condition from exhaustion consequent upon the loss of blood, and septic processes are likely to develop under these circumstances. The lowered vitality in hemorrhagic fever predisposes the patient to unhealthy inflammations, and great care must be exercised to guard against the onset of these pathological changes. The mental condition in hemorrhagic fever is characteristic. The patient is affected with a low form of muttering delirium, never becoming maniacal or violent. The intellect is restored in proportion to the general improvement in the symptoms. The distinguishing feature of hemorrhagic fever is that it is not due to absorption of any septic material, but is due chiefly to an altered nervous condition consequent upon the loss of blood, which fails to supply the proper nutriment to the great nerve-centers.

Spontaneous arrest of hemorrhage may be effected by a combination of several agencies. Contraction and retraction of the divided vessel and coagulation of the blood are among the means which nature adopts. Cardiac syncope is also sometimes a most important factor in bringing about an arrest of hemorrhage, because this condition of the heart reduces the force of the blood-current, and thus permits coagulation in the wounded vessel. Contraction of the middle and internal coats and retraction of the entire vessel within its sheath help to form a barrier to the exit of blood at the divided end of the artery. Coagulation of the blood is brought about by the diminished flow of blood and also by its exposure to atmospheric influences. The hemorrhage after laceration of the vessel is controlled by nature, owing to the fact

that the internal and middle coats curl up and the external coat and sheath are twisted over the open mouth of the vessel. This phenomenon explains the small amount of blood lost in cases where the extremities are torn from the body.

The **diagnosis of hemorrhage** is attended with no difficulty when blood makes its appearance externally. When the hemorrhage occurs within the great cavities of the body, and is therefore concealed, the diagnosis is fraught with uncertainty. Hemorrhage into the pleural, peritoneal, pelvic, or cranial cavity must be diagnosticated upon the special evidences manifest in each case. The general symptoms of hemorrhage are present, but in many respects they are so similar to those found in shock that a discrimination must be made with great care. (See p. 89.) The aseptic hypodermatic needle can sometimes be utilized with great advantage. If the hemorrhage is within the cranial cavity, the study of the nervous phenomena will aid in the diagnosis. (See Intra-cranial Hemorrhage.) If it is within the pleural, peritoneal, or pelvic cavity, physical signs will establish the diagnosis when taken in connection with the history of the case.

The **treatment of hemorrhage** is divided into constitutional and local. The *constitutional* treatment consists in the judicious administration of cardiac stimulants, such as strychnine, tincture of digitalis, carbonate of ammonium, nitro-glycerin, and hypodermatic injections of ether, brandy, or whiskey. As a rule, the remedies to excite the action of the heart should be given hypodermatically in order to secure an immediate effect, and great care should be taken lest the patient be suddenly over-stimulated. Ergot of rye has been used to cause contraction of the involuntary muscular fibers of the vessels. In view of the subnormal temperature, artificial heat should be applied to the surface of the body. This can be accomplished by warm blankets, bottles of hot water, and hot-air baths. In the use of bottles of hot water or hot-water bags care must be exercised lest the patient be burned, an accident as unfortunate as it is frequent. An enema of brandy, or of turpentine and hot water, can be employed as a valuable adjuvant.

The head should be placed low, to prevent cerebral anemia, and the patient kept as quiet as possible. An abundance of fresh air should be supplied to a patient suffering from profuse hemorrhage. The application of Esmarch's elastic bandage to the extremities, elevation of the arms and legs, and raising the foot of the bed should be employed, in order to increase the amount of blood in the brain and internal organs. Galvanism or sinapisms may be applied over the preordial region. Towels wrung out of hot water and applied to the head will help to bring about reaction. Warm fluids can be given as soon as the patient is able to swallow, and a good nutritious diet as soon as possible. Opium should be administered during reaction, especially if nervous excitement is present.

Transfusion after hemorrhage has been resorted to with marked success in cases in which a sudden loss of a large amount of blood has occurred. The operation of transfusion as formerly employed consisted in the injection of blood from a healthy person into the blood-vessels of a patient suffering from hemorrhage. It was attended with a high death-rate, and investigation into the causes of death demonstrated the fact that the mortality was due to the presence of emboli. Entrance of air was another source of danger. At present transfusion is employed, but instead of injecting blood a saline solution is generally used. (See Minor Surgery.)

The *local* treatment of hemorrhage consists in the arrest of the bleeding either by compression, ligation, torsion, or acupressure. If the hemorrhage proceeds from an injured vein, compresses should be placed over the wound

with uniform equable compression of the limb. This will suffice to control the bleeding in venous hemorrhage. If the hemorrhage is from a wounded artery, the bleeding vessel must be sought for and tied at both ends. The divided end of the artery, without any surrounding tissue, should be seized with a pair of artery forceps or hemostatic forceps, and the ligature should then be tied by means of the reef knot (Fig. 49). Catgut and sterilized silk are the materials employed for tying wounded arteries. Torsion of the vessel is applicable especially after amputation, as the vessel in this case is completely divided. In a wound in the continuity of the artery the vessel must be divided before torsion is applied. If the wound is a lacerated one, it can be converted into an incised one and the divided vessel caught and ligated or twisted. In applying torsion the vessel should be seized with the torsion forceps as if to ligate it (Fig. 50). A second pair of forceps may be placed upon the artery at right angles with and a short distance above the first pair. The open end of the artery is now to be twisted by the forceps on the long axis of the artery, which is held securely by the second pair of forceps. Only a few turns

FIG. 49.



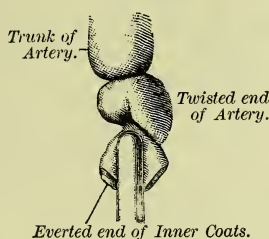
The Reef Knot.

FIG. 51.



Artery laid open to show Turning Up of Inner and Middle Coats from Torsion (Erichsen).

FIG. 50.

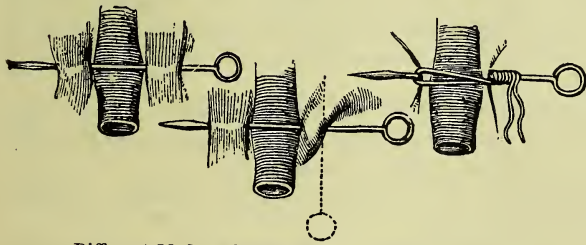


Effects of Torsion on Femoral Artery. (Bryant).

should be made or the end of the artery may be twisted off. The effects of torsion on the inner and middle coats of an artery are shown in Fig. 51.

Acupressure (Fig. 52) is occasionally useful; one method consists in passing a needle under the vessel and compressing it precisely in the same manner as the stem of a rose is fastened in the lapel of a coat by a pin.

FIG. 52.



Different Modes of Applying Acupressure (Bryant).

If the hemorrhage is capillary, gentle pressure can be employed. Hot water at 120° F. will act as an astringent, and is one of our most con-

venient and reliable means of arresting hemorrhage. Ice is sometimes employed. Heat and cold both act by stimulating the muscular fibers of the vessels to contract. The actual cautery is a powerful hemostatic, but it has the great disadvantage of causing a slough. Styptic cotton, though generally objectionable, may be useful in hemorrhage from places where the ligature is inadmissible. The position of the part, according to the laws of hydraulics, should be such as

to diminish the force of the circulation and to favor venous return. Elevation of the limb will accomplish this result if the wound is in an extremity.

Comparative Merits of Various Methods of Treatment.—In all cases of hemorrhage the constitutional treatment is the same. The local treatment, however, is subject to certain variations. The ligature or torsion is the preferable method. If catgut or sterilized silk is used for ligatures, both ends may be cut short, the wound closed, and primary union obtained. Acupressure possesses no special advantage over ligature or torsion since the principles of antiseptic surgery have been applied to wound treatment.

Transfusion should be employed in any case of hemorrhage in which the symptoms become alarming. A patient may have lost a great quantity of blood, and may even be apparently moribund, but if the heart's action is perceptible, transfusion is indicated. It has often saved life even under these extreme circumstances.

In the *after-treatment* of hemorrhage the patient should be kept perfectly quiet both physically and mentally, and all visitors should be excluded. Any tendency to syncope must be combated by lowering the head, and cardiac stimulants should be judiciously employed. The surface of the body should be kept warm by artificial means, and warm drinks be given until the equilibrium of the circulation is restored. A nutritious diet, fresh air, and hygienic surroundings should be provided. After the alarming symptoms have passed away, attention must be directed to the use of iron in some form, wine in moderate quantities, and a free diet. Oxygen may be inhaled several times a day with advantage. If the wound has been antiseptically dressed and drained, union by primary intention should follow. If it has been improperly dressed, or if, owing to some condition for which the surgeon is not responsible, suppuration is likely to follow, the wound should be thoroughly disinfected and free drainage provided, so as to repair the damage with as little constitutional and local disturbance as possible. From what has already been said in regard to the treatment of hemorrhage the following rules may be formulated:

1. (a) If *primary* hemorrhage is serious and bleeding is actually going on, apply an Esmarch bandage or a tourniquet above the injury to the vessel, open the wound, turn out the blood-clot, find the wounded artery, divide the vessel at this point, unless it has been already divided, and tie the proximal and distal ends with aseptic catgut.

(b) If primary hemorrhage is serious, but bleeding is not actually going on and the patient is in collapse, apply a tourniquet above the wound and stuff into it sponges soaked in hot 1 : 4000 bichloride solution, administer stimulants, and when everything is in readiness relax the tourniquet and proceed as already described under the first rule.

(c) In general oozing apply hot water (120° F.) by compresses. If an artery spurts from the sawn end of a bone, introduce an acupressure needle and lacerate the vessel or plug it with a strand of catgut.

2. (a) In *secondary* hemorrhage, if it is slight, open the wound or stump, turn out the coagula, and apply a compress.

(b) If the hemorrhage is alarming, apply a tourniquet or an Esmarch bandage, open the wound, and tie the ends of the vessel if possible. If this is not practicable on account of diseased or sloughing tissue, ligate the vessel above in its continuity according to the Hunterian method.

(c) If secondary hemorrhage occurs after ligation of a vessel in its continuity, apply a tourniquet, open the wound, turn out the clots, and tie the artery above and below the bleeding point if the tissues are not too much lacerated.

(d) If this fails, tie the artery higher up in its continuity, or amputate.

WOUNDS OF ARTERIES.

These may be punctured, contused, lacerated, gunshot, or incised. Besides the varieties just mentioned there may also be rupture.

A *punctured* wound is caused by the penetration of the artery by a sharp or a thin blunt instrument. If the opening is very small hemorrhage may not result, but if the puncture is of any size bleeding occurs. A punctured wound of an artery usually gives rise to a traumatic aneurysm, and must be treated as such.

A *contused* wound of an artery may be insignificant, or it may be of sufficient magnitude to cause gangrene by obliteration of the vessel or death by secondary hemorrhage. A slight contusion of the arterial wall may be followed by an inflammation which leads to a thickening of the walls of the vessel and complete occlusion. This condition may give rise to gangrene. If a thrombus forms in a contused artery which supplies some internal organ with blood, the viscus, having been deprived of its nutriment, will undergo degeneration. The contusion may be extensive enough to destroy the coats of the vessel, so that a fatal secondary hemorrhage follows the separation of the slough.

A *lacerated* wound of an artery deserves special attention, because the results are likely to become serious. If an artery is stretched or torn sufficiently, the middle and internal coats snap. In the middle coat the circular fibers separate from each other so as to leave a space, and the separated circular fibers contract upon the internal coat, which is torn completely across and curls up within the lumen of the vessel in the same manner as it does after the application of a ligature. In a lacerated wound of an artery the external coat is drawn out so as completely to lose its normal elasticity, in the same manner as a piece of rubber tubing will lose its elasticity when it is overstretched. Such an injury to an artery of large or small size may occur without any bleeding. The vessel is, however, permanently injured.

A *gunshot* wound of an artery derives its special importance from the fact that secondary hemorrhage is likely to occur. The vessel may be only contused by a bullet, and no bleeding occur until some days after the injury, when serious hemorrhage supervenes as a result of sloughing. A gunshot wound of an artery is often associated with injury to the accompanying vein, and an aneurysmal varix is formed. In case an extremity is blown off by shot or shell, the hemorrhage is often slight, on account of the fact that the vessels are lacerated, the middle and internal coats contract, curl up, and a plug is formed at the open end of the vessel. If, however, a rifle bullet enters the body when it is travelling at great speed, it may cut an artery like a knife, causing immediate and alarming hemorrhage. In addition to the primary or secondary hemorrhage which may be produced by a gunshot wound of an artery, the contusion of the vessel may lead to the formation of a thrombus, which may cause occlusion of the artery and be followed by gangrene. Pyemia is also a serious complication in gunshot wounds; and often a secondary hemorrhage ushers in a fatal septicemia.

An *incised* wound of an artery is an injury inflicted by some sharp cutting instrument. The hemorrhage is always profuse in such a wound, because there is no mechanical obstacle to the outflow of blood through the opening, such as is often found at the open mouth of a torn artery, and also because the contraction of the two ends of the vessel causes the wound in the artery to gape. The direction of the incised wound may be transverse, oblique, or longitudinal. The hemorrhage is very profuse in a transverse cut of an artery, while it is not so abundant in an oblique incision. If the artery is upon the stretch and is wounded longitudinally, the bleeding is very slight, but may become very

alarming when the artery is relaxed. In case of a partially divided artery the proper rule to follow is to divide the vessel completely and tie both ends.

Rupture of one or all of the coats of an artery is an injury that occurs under certain circumstances. The rupture may be partial, for example, when the internal and middle coats are torn and the external coat is stretched. This accident is not followed by hemorrhage, but it is a condition favorable to the production of secondary hemorrhage by sloughing, or to the development of an aneurysm. The same condition may also cause thrombosis or embolism of the vessel, and gangrene of the extremity or part may result. The rupture may be complete, in which case the artery is in the condition of a lacerated vessel. If it is subcutaneous, a traumatic aneurysm develops. If the rupture is partial and a clot has formed sufficient to occlude the vessel, then the pulsation below is lost and gangrene may supervene.

The **treatment** of wounds of arteries must necessarily vary according to the character of the injury. If the opening is of any size, the vessel should be completely divided and both ends tied. In case a traumatic aneurysm has developed as a result of a punctured wound of an artery, the rules prescribed for the management of this condition must be followed—*i. e.* it is a wounded artery, and should be treated as such.

If the *wound is a contused one*, the treatment consists in securing as much physical rest for the artery as possible by tranquillizing the circulation. This is effected by absolute rest and the administration of cardiac depressants. The possibility of the occurrence of secondary hemorrhage must not be forgotten, and measures to arrest it must be instituted immediately if it appears. The area or extremity which may be deprived of blood as a result of a contusion of an artery must be kept artificially warm in order to encourage the determination of blood to the part and to stimulate the collateral circulation.

If the *wound is a lacerated one*, the primary hemorrhage is usually slight on account of the curling up of the internal coat and the contraction of the middle coat, and the coagulation of the blood at the torn end of the vessel; but on account of the danger of secondary hemorrhage both ends of the vessel should be diligently sought, by a careful dissection if necessary, and securely tied.

If the *wound is a gunshot one*, the primary hemorrhage must be treated according to the same principles that would guide the surgeon in the management of an ordinary wounded artery. If the vessel is one of large size, digital pressure directly upon the artery and in the wound is indicated for the instantaneous arrest of the bleeding; in no case should styptics be employed. An Esmarch elastic bandage should now be applied, and the surgeon should cut down immediately upon the bleeding vessel, completely divide it at the seat of injury, and tie both ends of the artery with aseptic catgut. If the hemorrhage comes from an artery situated in the neck, or in any other place where the application of an elastic bandage is impracticable, the surgeon must be guided by the rules for the management of traumatic aneurysm. The dressing of such a wound should be conducted with the most rigid adherence to the principles of aseptic surgery in order to prevent secondary hemorrhage, a danger which is peculiarly frequent after gunshot wounds. The occurrence of gangrene is also a complication of an exceedingly fatal character in gunshot wounds, since septicemia rapidly develops. If the main artery of the limb is injured, and also its accompanying vein and nerve, even without a fracture of the bone, as a rule amputation is necessary to avert gangrene, which would almost surely follow.

If secondary hemorrhage occurs, it will be during the second or third week—that is, at the time when the sloughs separate. The bleeding should be arrested, if possible, at the site of the hemorrhage; but when this is impossible, a ligature

should be applied according to the Hunterian principle—*i. e.* in healthy tissue upon the proximal side of the wound. If the hemorrhage is alarming and it comes from several points, and the suppuration is extensive, with sepsis, amputation of the limb is indicated. The best way to prevent secondary hemorrhage is to keep the wound aseptic and to provide sufficient drainage. Good nutritious diet is required in order to maintain a high standard of vitality, which conduces to repair of the wound and averts the dangers of exhaustion, suppuration, and septicemia.

If the wound is an *incised* one and involves the neck or axilla, digital pressure must be promptly employed, and at once preparations should be made to search for the wounded vessel. This should be completely severed at the point of injury and a proximal and distal ligature of aseptic catgut or silk should be applied. If the incised artery is in an extremity an Esmarch bandage can be applied in the same manner as already described in the management of primary hemorrhage in gunshot wounds. The application of the bandage permits the surgeon to make a bloodless dissection and secure with certainty and ease the wounded vessel.

In case of a *ruptured* artery the treatment is practically the same as would govern the surgeon in the management of a contused or lacerated vessel.

WOUNDS OF SPECIAL ARTERIES.

The **carotid artery** may be wounded as a result of gunshot injury, a stab, or other wound, or during the performance of an operation upon the neck. The wound of so large a vessel is necessarily a most serious event. If the vessel is entirely cut across, the patient usually (but not always) expires in a few minutes; but if the carotid is partially wounded, the hemorrhage may be arrested by compression until the vessel is secured and ligatured. This artery is seldom divided in an attempt at suicide, especially when the head is thrown back, because of its anatomical situation deep in the neck; but the superior thyroids lying in front and more superficially are often wounded; the incision rarely extends deeper than these vessels. In all cases of wounds of these larger vessels of the neck the treatment is based upon the general principles which govern the surgeon in his management of hemorrhage. A primary hemorrhage should be treated by dividing the vessel at the point of injury, if not already divided, and instantly tying both ends of the vessel. A secondary hemorrhage must be controlled by methods already mentioned. In wounds of the carotid and its branches the possibility of the occurrence of œdema glottidis must not be overlooked, and a prophylactic tracheotomy should be performed if this occur.

The **vertebral artery** may be injured in any of the ways mentioned in reference to wounds of other vessels. Compression has effected an arrest of the hemorrhage; but, as a rule, a search for the wounded vessel may be made, and if possible the artery be divided and tied at both ends. There is danger of escape of blood into the spinal canal and compression of the cord when a wound of the vertebral artery occurs.

The **subclavian artery** has been wounded in the various ways that have been described, and possibly by a puncture from a fragment in fracture of the clavicle or of the first rib. A wound of this vessel is most serious on account of its size and its situation. A large traumatic aneurysm is developed, and must be treated after the manner described in the management of such an aneurysm.

The **axillary artery** is subject to the same injuries as other vessels, and

is additionally exposed to the danger of rupture in reducing old dislocations of the shoulder-joint. Fortunately, in the wounds of the axillary artery due to complete laceration of the vessel the artery retracts and contracts and the hemorrhage may be spontaneously arrested. In injuries of this artery, as a rule, the vessel should be exposed, completely divided, and both ends secured by a ligature. In rupture from attempts at reducing an old dislocation this procedure has been uniformly fatal, and should be replaced by compression, ligature of the subclavian, or amputation at the shoulder-joint.

The **femoral artery** is often exposed to injury, and on account of its superficial situation the hemorrhage is easily controlled. The same rules govern the surgeon in the management of wounds of this vessel as in those of other arteries. After ligation of the artery the limb should be elevated and artificial warmth should be applied to prevent gangrene.

The **popliteal artery** is seldom wounded, owing to its deep situation and to the protection which is afforded to it by the joint in front. In case of an injury to the vessel an Esmarch bandage should be applied, the vessel found, and both ends of the divided artery ligated.

In case of a wound of any of the other arteries in the body—in the forearm, arm, leg, or foot, or upon the trunk—the principle of searching for the bleeding vessel and ligating it at both ends must always be kept in mind. The hemorrhage from an intercostal or from the internal mammary is serious, because generally some of the thoracic viscera are also implicated. It has been suggested to introduce a finger-shaped tampon made of a piece of antiseptic gauze, which is pushed between the ribs with a probe, and then to fill the tampon with strips of iodoform gauze and draw the entire mass outward, so as to make firm pressure against the inner wall of the thorax and the two corresponding ribs. It is, however, best to secure the two ends of the divided vessel by ligatures in the manner already described. A rib may be resected if necessary.

WOUNDS OF VEINS.

A wound of a vein is in some respects less dangerous than a wound of an artery of the corresponding size; but serious complications may readily follow a wound of a vein, unless kept aseptic. The hemorrhage from a *small vein* is less than that from an artery of the same size, because the vein collapses and the force of the circulation is not so great as in the corresponding artery. A considerable quantity of blood is extravasated in the surrounding tissues, so that external pressure will also contribute to the arrest of the hemorrhage. The loss of blood from a *large vein*, however, is so rapid and excessive as to endanger life in a few minutes.

The **symptoms** of venous hemorrhage upon which the **diagnosis** is based, are—1st, the escape of dark-colored blood in a continuous stream; 2d, the special effects of pressure: if applied upon the distal side of the wound, it causes the hemorrhage to cease; but it causes it to increase if the pressure is applied upon the cardiac side of the wound.

The **complications** that follow an injury to a vein depend chiefly upon the size of the vessel and upon the septic or aseptic conditions attending the injury. Among the complications are phlebitis, œdema, thrombosis, embolism, ulceration, metastatic abscesses in organs directly connected with the wounded vein, gangrene, and secondary hemorrhage.

The **treatment** of a wounded vein depends upon the size and situation of the vessel. If the vessel is small and situated superficially, elevation of the limb, a compress applied upon the distal side, and rest will be all that is neces-

sary. If the vein is large and deeply situated, the injured vessel should be found and both ends of the divided vein secured by an aseptic ligature. Of course thorough asepsis of the wound must be secured. If the wounded vein is within one of the three great cavities of the body, an operation of great magnitude may be indicated in order to reach the bleeding vessel. If a vein is wounded laterally, the slit can be picked up with a pair of forceps and a ligature applied to it, so that the lumen of the vessel will not be obliterated. In the case of a large vein where the tissues are abundant this method of treating a wounded vein has many advantages. Hemostatic forceps may be applied and left *in situ* for forty-eight hours. They should of course be entirely covered by the dressing.

WOUNDS OF SPECIAL VEINS.—A wound of the **internal jugular vein** is generally quickly fatal from the loss of blood or occasionally from the entrance of air into the vein. The direction of the wound influences the prognosis, because a longitudinal slit will not gape, while a transverse one is held wide open by the action of the deep cervical fascia. If the internal jugular is wounded near its entrance into the skull, besides the dangers arising from the loss of blood and also the entrance of air, there is the additional danger of cerebral septic infection and venous and sinus thrombosis.

Injuries of the **subclavian** and **axillary** veins are also very serious, for the same reasons that have been mentioned in reference to the jugular vein.

A wound of the **femoral vein**, besides the loss of blood, has an additional danger—gangrene of the leg—which may follow the ligation required to arrest the hemorrhage. Ligation of the popliteal vein may also be attended with the same complication. After either of these ligations the limb should be elevated to help the venous return, and be enveloped in cotton and hot-water bottles to keep up the temperature of the leg. If gangrene intervenes, amputation must be done.

For Wounds of the Cerebral Sinuses see Injuries of the Head.

CHAPTER II.

SURGERY OF THE OSSEOUS SYSTEM.

As the osseous tissue differs in no material respect from the soft parts except in the added lime-salts that give it firmness, its injuries and diseases are in the main of like character and course, wounds, inflammations, and tumors terminating in more or less complete return to the normal state or in constructive or destructive changes. The soft structures in the cancellous and medullary spaces, in the Haversian canals, and upon the exterior of the bone, though for convenience' sake and with a seeming anatomical and pathological basis they may be separately considered, are but parts of a common whole, a lesion of which may be general or limited according to its nature and intensity.

The most numerous and important affections are the inflammations consequent upon injury; upon the existence of special diathetic states, as the tubercular or syphilitic; upon a general infective disease, as typhoid fever; or upon the presence and action of pyogenic organisms. They may be *acute* or *chronic*, and end in resolution, in organization of an exudate, or in destruction, limited or extensive, molecular or in mass, of the part involved. According to the presence or absence of the pyogenic microbes suppuration will or will not occur.

Liquefaction to a greater or less extent is an ordinary effect of the syphilitic invasion, still more of the tubercular. The intensity of the symptoms is always greater in the suppurative than in the non-suppurative affections. The pyogenic organisms (generally the staphylococcus aureus or, but much less frequently, the streptococcus pyogenes) gain admission to the diseased area either through an open wound or by the blood-stream, having been taken up at some distant and often small pus-dépôt, or by the lungs, or the intestinal canal, to which they have been brought from without the body.

These inflammations may be considered under the general heads of *osteoperiostitis* and *osteo-myelitis*, since pure periostitis is of very infrequent occurrence, perhaps is only met with as a syphilitic manifestation, and pure myelitis is equally infrequent.

OSTEO-PERIOSTITIS.

This condition usually exists in cases commonly thought to be examples of periostitis, in which not only the periosteum, but the superficial layers of the bone also are diseased. It may be acute or chronic, plastic or suppurative, limited or diffused. It is the result of cold, of wounds or contusions, of strains from undue traction on inserted tendons, of contiguous inflammations, as from old ulcers, or of special infections, syphilitic, tubercular, or pyogenic. The more superficial the bone, the more likely is osteo-periostitis to occur, because of the greater exposure to injuries and the action of cold. The periosteum both in its outer and inner layers is thickened and reddened and its cells increased in number. More or less of the surface of the underlying bone is similarly affected, and its blood-supply may be so diminished in consequence of the separation and occlusion of the vessels by the swollen periosteum as superficially to destroy its vitality. When neither suppurative nor tubercular, the disease terminates either in resolution or in permanent thickening with new formation of bone, or, but much more rarely (and chiefly on the head in cases of syphilis), in thinning and absorption.

When suppurative and limited, after evacuation of the pus repair takes place with either little or no thickening, with decided hypertrophy, or with some loss of substance. When diffused, unless very promptly arrested, extensive destruction of membrane and bone commonly follows. These purulent varieties are rarely, if ever, primary, though the antecedent deeper inflammation may be but slight.

The **symptoms** vary somewhat according to location and cause, being least marked in the traumatic non-suppurative cases, but pain and swelling are always present, the former, as a rule, severe and worse at night. If it is a deeply-situated bone that is affected, it is often impossible to recognize the swelling, but if a subcutaneous one, for example the tibia, as is so frequently the case, the spindle-shaped thickening can be readily felt; there is much tenderness on pressure and the overlying soft parts are œdematous and reddened. In the suppurative varieties constitutional symptoms are present, and are of a high grade in the diffused phlegmonous form. In the chronic syphilitic inflammations the pain is, as a rule, not acute.

The **treatment** in the beginning is by rest and the application of either cold or heat as is more comfortable to the patient.

If speedy resolution does not take place and the pain is great, subcutaneous punctures of the swelling should be made, or, if pus is present, the parts should be freely laid open. When the disease is due to syphilis, the knife should not be used, but reliance should be placed upon the administration of the ordinary antisiphilitic remedies.

OSTEO-MYELITIS.

Osteo-myelitis (which includes both osteitis and medullitis—*i. e.* myelitis of bone) is the more common form of bone inflammation, the cause of which may be either local, general, or septic.

As in inflammation of the soft tissues, the parts are congested, the blood-vessels dilated, effusion and exudation take place, and there is increased cell-growth. If the disease is slight and due to traumatism, and if resolution quickly follows, no organic change is produced in the bone-layers; but ordinarily there occurs more or less destruction, either in mass (**necrosis**) or molecular (**caries**), limited or extensive according to the degree of the inflammation and its exciting cause. In necrosis the dead part is called a *sequestrum* (p. 264). When perforation of the overlying tissues has taken place, upon probing necrosed bone is to be recognized by its hardness and its sharp, clear percussion note when struck, carious bone giving out a dull sound, if any, and being generally readily penetrated by the instrument.

These two forms of bone-death are to the osseous system what gangrene and ulceration are to the soft parts—necrosis, like gangrene, being due to a cause which directly or indirectly cuts off the blood-supply to or interrupts the outflow from an area large enough to be recognizable by the unaided eye; while in caries, as in ulceration, the cells of an abnormally succulent part melt down and are discharged.

As met with in practice, necrosis is commonly due to a non-traumatic infective inflammation. At times it is consequent upon injuries (*e. g.* fractures permitting of the entrance of pyogenic organisms or severe contusions), or, less often, exposure to severe cold or high heat. In the bones of the head and face it not rarely is of syphilitic origin.

Caries—the ulceration of bone—is almost always due to tubercular infection.

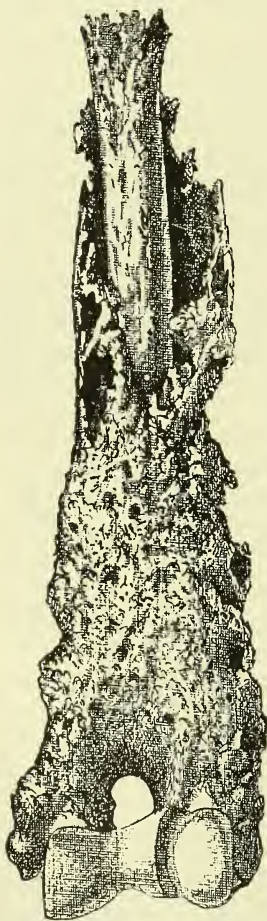
Osteo-myelitis is either acute or, more frequently, chronic. If the inflammation is acute and severe, the resistance of the rigid walls of the central cavity and of the Haversian canals generally causes such compression of the vessels (which often become strangulated by the newly-formed cell-masses) that the vitality of the part cannot be preserved; necrosis then necessarily results (Fig. 53). Such death in mass in greater or less measure is always to be looked for in the acute infective or suppurative inflammations.

When the process is a slower one, there may still be an arrest of circulation with resulting necrosis, but generally the death of the bone-layers is a molecular one, due in part to the disintegrating action of the excess of fluid, but chiefly to the pressure made by the enlarged vessels and the newly-formed cells and to the destructive action of the latter. These are especially abundant in the Haversian canals over the flexures of the vessels, and as a consequence the walls of such canals break down unevenly and are pitted, the depressions being commonly spoken of as the *Howship lacunæ*. As the result of the softening and disappearance of the bone the cancellous spaces enlarge, the central cavity widens, and the Haversian canals increase in diameter, granulation-tissue becoming more and more abundant and progressively occupying the places from which the bone has been removed. In other words, a condition of *osteoporosis* has been developed, and the affection is a *rarefying osteitis*, which may be, on the one hand, of very limited extent, or, on the other, involve a large part of the bone, even from center to cortex. Outside the area of rarefaction there will often be found a space of greater or less width in which formative changes have occurred, the bone being thicker and denser than normal, *osteo-*

sclerosis instead of *osteo-porosis* being present. Such secondary changes may affect parts of limited extent previously in a state of rarefaction, which when the inflammation has entirely disappeared will remain unduly hard, with their Haversian canals abnormally narrow.

During the rarefying action small pieces of bone may be destroyed and separated (necrotic caries). The great majority of the cases of caries, nine-tenths if not more, are of tubercular origin, the deposit taking place readily, as the result of slight traumatisms, in the cancellous tissue, the vessels of which are numerous and thin-walled and the capillaries very large in proportion to the size of their associated arteries and veins. It is during the years of growth

FIG. 53.



Necrosis of the Diaphysis, following Acute Osteo-myelitis of the Humerus (Duplay and Reclus).

in the parts of the bone in which such growth chiefly occurs, as about the epiphyseal lines and in those portions of the skeleton particularly subject to blows, shocks, and the action of cold, that this form of disease is ordinarily observed.

Here as everywhere else the bacilli cause softening of the parts immediately about them. If few in number and limited in action, they may be rapidly destroyed or shut in, so that either by cicatrization or encapsulation recovery takes place. This often occurs; in the great majority of cases, however, the disease is not so arrested, but infected granulation-tissue continues to be developed in the cancellous spaces, in the Haversian canals, and in the central medulla, more and more bone is softened down or pieces of appreciable size are deprived of their blood-supply, and consequently die. Thus the tubercular area grows larger with accompanying liquefaction and caseation, and the rarefaction extends farther and farther.

When it is the presence and action of the pyogenic microbes that excite the inflammation the osteomyelitis may be either acute or chronic, limited or widespread, with accompanying destruction of bone and corresponding intensity of local and general symptoms. Though there are a number of the pyogenic organisms that may cause these septic diseases of bone, the *staphylococcus aureus* is the one most commonly met with, and next to it the *streptococcus pyogenes*.

Associated with certain of the acute infectious diseases, especially typhoid fever, there occurs an inflammation, generally superficial, which causes a necrosis commonly of limited extent and with a strong tendency to become symmetrical—*e. g.* to simultaneous or consecutive development in like parts on both sides of the body. Whether because the dis-

ease-germ is itself pyogenic or because of a double infection, these typhoid inflammations are as a rule suppurative. Osteo-sclerosis is a very frequent effect of syphilitic infection, but both necrosis and caries often occur, and in different portions of the same skeleton the three forms of osteitis, condensing, rarefying, and hypertrophic, may be observed.

In phosphorus-workers severe and extensive necrosis of the jaws is at times,

though now very rarely, produced by the action of the poison that has gained access to the bone through decayed teeth.

Acute osteitis is either *simple* or *septic*.

Simple acute osteitis is consequent upon traumatism, and occurs in parts protected against the action of the pyogenic micro-organisms either by an unbroken soft covering or by antiseptic treatment. It is of comparatively little importance, and usually terminates by resolution in a short time. Its symptoms are few. Pain is the most prominent symptom, and is often not severe; it is apt to be deep-seated, boring or gnawing, worse at night, aggravated by the dependent position, and increased by pressure. If it is superficially located—when, indeed, it is an osteo-periostitis rather than a simple osteitis—it may be associated with some œdema of the soft parts and discoloration of the skin. Rest, elevation of the limb, fomentations, and moderate compression are the local remedial measures to be adopted, pain being controlled by opiates. If the suffering is very severe and does not quickly subside, the overlying soft parts should be incised, and if this does not relieve, the bone should be aseptically drilled at one or more points, thus lessening the tension.

Of the **septic inflammations** of bone there are *two varieties*: (1) the one associated with an open wound, originating ordinarily in the shaft of a long bone and generally met with in adults; (2) the other, without such associated wound, beginning in the parts near the epiphyseal line. The latter is peculiarly a disease of childhood. It may, however, occur later in life, and is then in the great majority of instances a recurrence of a similar inflammation of early life, some of the causative germs of which had been encapsulated. Boys are attacked three times as often as girls, and nearly half of the patients are adolescents between the ages of thirteen and seventeen.

The *first variety*, since the introduction of antiseptic surgery, is comparatively rare. Typical examples in former years were often seen in cases of compound fracture, especially gunshot fractures, and after amputations, infection of the wound having taken place at the time of injury, during the operation, or later. The severity of the inflammation varies, from that in which there are but little suppuration and limited destruction of bone to that in which the parts quickly become putrid; the whole bone is destroyed, and the patient dies early of septicemia or pyemia, even within twenty-four or forty-eight hours, in the most malignant of the latter cases.

When associated with a *compound fracture*, in addition to the ordinary conditions, such as congestion, extravasations, and cell-development, following an injury of this character, pus is present, with the general symptoms commonly attendant upon suppuration. Since the great danger lies in the development of septic infection, the local treatment should consist in securing free drainage and in rendering the diseased area aseptic.

When the disease arises after *amputation*, the medulla appears discolored by extravasated blood, and in the severer cases bleeds upon slight pressure and protrudes beyond the level of the sawn surface, at times to a large extent, covering the end of the bone with a fungous mass. The discharge is abundant and sero-purulent, often having a very offensive odor. As the result of the inflammation, when the constitutional infection is not such as to cause early death, the bone about the medullary cavity necroses, and after a time is separated in the form of a tubular sequestrum (Fig. 56), much worm-eaten on its exterior, of greater or lesser length, thick at the base, irregularly thinning out higher up, and ending in sharp points. The constitutional symptoms, increase of temperature, acceleration of pulse, mental hebetude, etc., are of varying intensity.

The local treatment should consist in the free removal of the infected medulla and in curetting the walls of the cavity, followed by its thorough disinfection and drainage and by antiseptic dressing of the stump, thus limiting, as far as possible, the extension of the septic inflammation. When the dead bone has been loosened from the living, chiefly by a process of rarefying osteitis in the latter, it should be promptly removed, since, its extrusion unaided by surgery would be effected slowly, and while in progress there would be liability to extension of the suppurative inflammation, with further destruction of bone.

The *second variety*, **acute epiphysitis**, arises when the pyogenic organisms have not found entrance through an open wound, but have been brought to the affected area in the blood-stream. The effect then produced is very variable. In a comparatively small proportion of cases intense and rapidly-destructive inflammation of the bone follows. It is this variety of osteomyelitis that is most frequently met with at the present time, wounds involving bone, however produced, being protected in the great majority of cases against the action of the pyogenic cocci by aseptic and antiseptic treatment, provided they come under the care of the surgeon before infection has taken place.

FIG. 54.



Arrest of Development of the Ulna following Osteitis near Epiphysis; continued Growth and Deformity of the Radius (Poncet).

As has been stated, it is a disease of childhood and adolescence, and has its starting-point in the tissues near an epiphyseal line, due to the frequency of juxta-epiphyseal strains, the femur and the tibia being the bones most commonly affected. Fig. 54 shows arrest of development of the ulna followed by deformity of both ulna and radius consequent upon such an inflammation near the epiphyseal line of the ulna.

The **symptoms** are, in the beginning, high fever (with often an initial chill), delirium, and great pain, gnawing or boring in character and located ordinarily near the end of a long bone, with a peculiar helplessness of or inability to move the limb by its own muscles. The attack comes on suddenly, generally at night, after exposure to cold and dampness, combined sometimes with unusual exertion. Sitting on a stone doorstep and unduly prolonged swimming are common causes, even in summer. If the inflammation is at first deeply seated in the cancellous tissue, no change in the overlying soft parts, either in thickness or in color, will be observed for a number of days, even in the graver cases, though there is from the first sensitiveness to pressure over the affected area, and frequently the superficial veins are abnormally distinct. Before long, however, the external layers of the bone and periosteum become

involved, and swelling of the soft parts and redness of the skin occur, with quickly-following fluctuation, indicating the presence of pus. When the disease originates near the surface, these latter symptoms will be noticed early, the rapidly-forming and widely-spreading pus lifting the periosteum off the shaft for a variable distance, in the graver cases from end to end and around the

whole circumference of the bone. The temperature continues high, with daily fluctuations of two, three, or more degrees, and the pain is excessive until tension is relieved by the spontaneous opening of the abscess or by operation. As soon as there is such an opening, probing will almost certainly reveal the presence of dead bone. The neighboring joint generally soon becomes inflamed, with resulting effusion into its capsule, the fluid often becoming purulent after a time, either from direct communication with the suppurating area in the bone or from transmission of the pyogenic cocci through the blood-vessels or the lymphatics.

In young children the acute epiphysitis that at times occurs is very apt to cause separation of the epiphysis, followed by suddenly produced displacement, resulting in shortening and deformity (Fig. 54). This variety of bone-inflammation is usually located at the hip, knee, or shoulder.

At times, though not often, the pyogenic organisms are carried from one end of the bone to the other without involvement of the intervening shaft, two entirely distinct areas of inflammation being produced in the same bone.

The intensity of all the symptoms will vary according to the character and number of the infecting organisms. In the most severe cases, fortunately very rare, only pain and the temperature and typhoid state of an acute septicemia are observed, death occurring quickly. Generally, swelling and abscess-formation are added. These abscesses are extensive and developed early in the graver cases, but are limited and appear more slowly in the milder ones, the latter being those more commonly met with. In certain cases the attack may be so mild that pus is not formed, but a synovia-like fluid, chiefly subperiosteal, the nature of which is not discovered until after its evacuation; or perhaps pus is formed and undergoes a later mucoid degeneration. This *periostitis albuminosa* has been observed only a very few times.

The **diagnosis** in the earlier hours or days may be uncertain, the affection being often regarded as a typhoid fever or an acute rheumatism, or, in the periosteal variety, because of the redness of the skin, as an erysipelas. But if due regard be had to the age of the patient, the location of the pain close to but not in the joint (commonly the knee, the ankle, or the hip), its peculiar gnawing, boring character so indicative of bone-inflammation, and the suddenness of appearance and severity from the start of the constitutional symptoms, with the absence of the progressive daily rise of temperature that belongs to typhoid fever in its first week, there will seldom be any doubt as to the nature of the disease.

The **prognosis** as respects both part and life is grave. Death from septicemia in a few intensely infective cases takes place so soon (within one, two, or three days) that its osteo-myelitic origin is not recognized. When it originates superficially, the disease is less dangerous than when of central origin, as the pus more readily and rapidly reaches the surface and is more quickly evacuated.

Though the prognosis is much affected by the intensity of the inflammation, it is more influenced by **treatment**. This to be effective must be operative, and the sooner the diseased area is cut down upon and the bone drilled or trephined, the greater the likelihood of arresting the inflammation and lessening the local destruction. The application of heat, pressure, tincture of iodine, etc. will not stop the disease; tension must be relieved, pus evacuated, the bone trephined and the bone cavity scraped, and the parts irrigated with a sublimate solution in order to kill the staphylococci.

When the medulla is extensively involved, much benefit will follow trephining at two different levels or at many points, scraping out the intervening

infected tissue, even to the removal of the whole medulla of a long bone, such as the tibia, and thoroughly irrigating with antiseptic solutions. In the superficial variety (even in the so-called acute phlegmonous periostitis), when the periosteum has been extensively separated, it may regain attachment to the bone to a large extent after early free incision and irrigation and the vitality of the shaft in the main be preserved.

If, as is generally the case, from neglect of treatment or in spite of it, necrosis has resulted, the dead bone should be removed as soon as it has become detached; but often in the more severe cases, in order that the profuse discharge and progressive exhaustion may be stopped, an early operation will be required at the end of four, five, or six weeks, even at the risk of taking away too much or too little of the shaft and having little or no regeneration of bone follow.

FIG. 56.

FIG. 55.



Superficial
Sequestrum
(original).



Tubular
Sequestrum
(original)

SEQUESTRA—The dead piece of bone, whether large or small, is called a **sequestrum**; when upon the exterior it is *superficial* (Fig. 55); in the interior it is *central*; when of limited thickness, but involving the entire circumference, as after amputation, it is *tubular* (Fig. 56) or *ring-shaped* according as it extends for a considerable distance up the bone or is confined to the sawn end; when it embraces the whole shaft, with or without the epiphysis, it is *complete*. For a long time the fragments in a compound fracture have been spoken of as sequestra—primary when completely separated at the time of the injury, secondary when for a time held by periosteal or muscular attachments, and tertiary when later destroyed by inflammation; but the term should be restricted to the latter, since the others are not at first dead nor in a large proportion of cases will they die if suppuration be prevented.

When not exposed to the air, sequestra are almost always of a dull-white color; when so exposed, they are generally black. When struck by a probe, the note is clear and high-pitched, altogether different from that given out by healthy or by carious bone. The orifice of a sinus communicating with the sequestrum is more or less open, the granulations are pouting, and the bony rim is firm to the touch.

When the periosteum with its deeper layer is not destroyed, and especially when the external layers of the bone are living, if sufficient time is afforded for the production of new bone an osseous envelope is formed, called the **involucrum**. This more or less completely shuts in the sequestrum, whose outer surface is either smooth if the new formation is of periosteal origin, or rough and worm-eaten if the separation has been produced by a rarefying osteitis.

Where there has been ulceration through the periosteum and bone-layers outside the sequestrum, no such re-formation occurs at these points, and the involucrum is pierced by openings of a size corresponding to the parts destroyed; these openings are called **cloacæ**. Plate X shows on the exterior the involucrum pierced by numerous cloacæ and on the interior the sequestrum of the entire shaft of the femur, the result of an acute osteo-myelitis.

When the necrosed piece is central, the living bone about it often becomes so sclerosed that it can be cut through only with difficulty. Occasionally,



Sequestrum of entire shaft of femur, involucrum riddled with cloacæ; the result of acute osteo-myelitis.

though rarely, this condensed bone is not perforated by even a single sinus and the sequestrum is completely enclosed. (Pl. XI, Fig. 1.)

The separation of the dead bone from the living is a comparatively slow process, occupying two, three, or more months, but it should nearly always be waited for when removal by operation is to be effected, so that only the dead bone may be taken away and time be afforded for the formation of a firm involucrum: the only exception to this rule is found in those more severe cases of acute osteo-myelitis in which an early removal is demanded in order that fatal exhaustion from profuse suppuration may be prevented. That such separation has taken place may generally be recognized by the mobility of the sequestrum when pressed upon through one or more of the cloacæ, though occasionally movement is prevented by the firm hold of the granulations upon the dead piece. Detachment from the living bone must then be inferred from the length of time that has elapsed. Though a non-infected sequestrum may in very rare instances be absorbed or remain shut in and innocuous for a long time, dead bone, as commonly met with, is an irritating foreign body, which must be got rid of either by spontaneous extrusion, by chemical solvents, or by operative removal before a healthy condition of the affected region can be secured. Small sequestra, especially superficial ones, may make their way to the surface and be thrown off, but the process is a very slow one.

Treatment by the application of a dissolving fluid, such as dilute nitric or hydrochloric acid, is uncertain, tedious, and to be advised only in those rare cases in which the sequestrum is so placed that it cannot readily and safely be got at by operation. In the great majority of cases the removal of the sequestrum will be by operation—sequestrotomy.

Sequestrotomy.—When practicable, the parts should be rendered bloodless by the Esmarch bandage, or, better, when the disease involves an extremity, by elevation for four or five minutes, followed by the application of the rubber band. If there is a cloaca large enough to permit of the introduction of a forceps, the dead bone is seized through it, and if of small size is dragged away. When necessary the opening should be enlarged and the sequestrum divided before removal. When the necrosed piece is a large one it will generally be necessary to cut away with chisel or gouge a portion of the involucrum, it may be for nearly the entire length of the bone. The dead bone having been lifted out, the granulations in which it has rested are to be thoroughly scraped away, the parts well irrigated, the cavity stuffed with iodoform or other antiseptic gauze, an antiseptic dressing applied, and the limb immobilized. When the involucrum is quite thin or imperfectly developed, it may be broken in the removal of the sequestrum, but repair, as a rule, readily and rapidly takes place after immobilization. Usually the progress of the case is very satisfactory: the cavity more or less completely fills up by the formation of new bone, and after a few weeks the patient can begin to use the part if, as is generally the case, the operation has been done on one of the extremities. Only rarely, and when there has been great general weakness or when the wound becomes infected, is the result a fatal one. If the gap in the bone is long and deep, much of the involucrum having been cut away, an effort should be made to fill it up, either by an organizable blood-clot, by bone-chips, by breaking down and bending in the edges of the involucrum, or by skin-flaps turned in and attached at the bottom; preferably the first or second. The decalcified bone-chips, originally employed by Senn, generally serve the purpose of a framework or scaffolding on which new bone is built up, the chips themselves undergoing absorption. In Lücke's "Osteoplastic Necrotomy," in the shafts of the long bones a longitudinal incision is made through

the skin and periosteum, as nearly as possible in the line of the cloacæ, and a section of involucrum chiseled out corresponding with this incision. At either end where the sequestrum-cavity terminates the soft parts are divided transversely and the bone correspondingly chiseled through. With a small chisel the base of the skin-periosteum-bone-flap, thus obtained, is divided from within the sequestrum-cavity so that the entire flap may be turned back out of the way. Such a flap may be made on one or both sides of the cavity. After cleaning out the bone the flaps are bent inward so as to fill the cavity as far as possible. In order that success may follow the adoption of any of these methods the wound must be made aseptic and kept so.

THE CHRONIC INFLAMMATIONS OF BONE.

The **chronic inflammations** of bone are generally such from the beginning. They are of much more frequent occurrence than the acute, and, like them, are of pyogenic, syphilitic, malignant, or tubercular origin. They are very rarely traumatic and unassociated with pyogenic infection, though, as is seen in the vertebræ pressed upon by an aneurysm, ulceration from prolonged, frequently-repeated injuries may take place.

The prevailing type is the rarefying. Molecular death occurs to some degree in all cases; death in mass results chiefly in those due to syphilitic or pyogenic infection; often extensive new formation, both in length and thickness, takes place in the syphilitic, and, to a certain extent, in the pyogenic.

The diseases induced by the different causes are located by preference in different parts of the skeleton: thus, syphilis infects chiefly the long bones and those of the head and face; sarcoma and carcinoma, the long bones, the pelvis, and the jaws; pus infection, the long bones; tuberculosis, the bones of the hands and feet and the spongy tissue in close relation with the hip-, knee-, and elbow-joints.

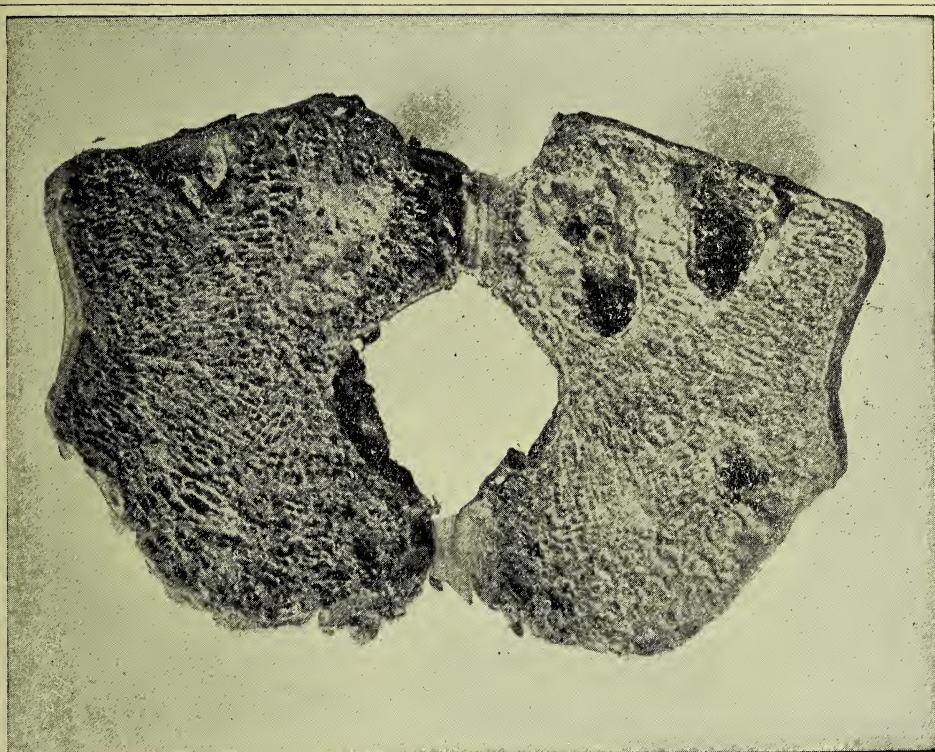
Children and adolescents are the ordinary subjects of osteo-myelitis, tuberculosis, and inherited syphilis; young adults, of sarcoma, acquired syphilis, and the relapses of the inflammations of youth; persons of middle and advanced life, of syphilis and cancer.

Symptoms.—Pain is the most common symptom, its intensity, however, being very variable even in cases having a like origin. As a rule, it is worse at night, the increased fulness of the veins and capillaries due to the more sluggish circulation making greater the tension-pressure upon the nerve-fibers. It is aching, gnawing, boring, or, in tubercular cases in which there is inflammation of the subarticular layer of osseous tissue, starting.

With or without the development of an abscess a sinus may form, through which more or less discharge may take place, the discharge being often gritty or having in it small yet readily detected spicules of bone, showing, as does the bone itself, that the affection is truly a caries or decay of the osseous tissue.

When the inflammation is located upon the surface, examination by the eye, the finger, or the probe, or of the cleaned and dried specimen, shows that the process is an ulcerative one, producing an ulcer with all the characteristics of an ulcer of the soft parts; and the same is true, certainly as respects the process, when it is centrally developed. The granulations may be numerous and moist, as is commonly the case, or large and abundant with little fluid (fungous caries), or very feebly developed with no discoverable fluid (dry caries), as in a few cases of syphilitic or tubercular origin.

This **caries sicca** is frequently observed upon the skull and in the upper ends of the humerus (Fig. 57) and femur. The bone-destruction is



Tubercular foci of the lower end of the femur.



Central sequestrum and osteo-sclerosis.

often extensive, and in the long bones is due in a measure to the wearing effect of the pressure of contiguous parts. Not seldom its existence is indicated only by impairment of function and by severe pain, very persistent, and irremediable except by removal of the diseased part.

This form of osteitis, if left to itself, (1) may terminate in arrest of formation of the granulations, absorption or elimination of the dead tissue, and sclerosis of the new layers and of the parts around, with or without overgrowth of the affected bone, which when it occurs causes permanent alteration even to the extent, it may be, of marked deformity; or (2) may continue for a long time without material local change or the development of visceral lesions; or (3) may often slowly but steadily advance, destroying more and more widely the bone, involving other portions of the skeleton, causing marked general debility, and inducing grave disease of internal organs, especially the lungs, the kidney, and the intestine.

The **treatment**, in general, is made up of measures calculated to relieve irritation and to hasten the elimination of dead tissue—measures therapeutic and operative, considered in detail under the separate heads of the various classes of bone-inflammations, septic, specific, malignant, and tubercular.

Tubercular Inflammation of Bone.—The most frequent and most typical of these inflammations is the *tubercular*, and is often secondary to some distant primary focus of the disease. Infected granulation-tissue forms more or less rapidly, showing, as a rule, comparatively few bacilli, and these chiefly in the new growths farthest from the point or points of original deposition; such tissue, by its pressure and after-caseation with its associated fluid, produces wasting of the osseous trabeculae.

Caseation and liquefaction so affect the cells of the growth that, together with the altered layers of bone, they may be scraped away as grayish-yellow masses saturated with fluid. At times little or no fluid is to be seen, though the bone has become so soft as to be easily cut with a knife. Cavities, larger or smaller, few or many, filled with fluid degenerated cells and bone detritus, are of frequent formation (Pl. XI, Fig. 2). In the long bones infiltration of the medulla of the central canal may occur throughout its length or be limited to a few distinct areas. Usually, however, the new growth is in the cancellous spaces of the extremities and in the Haversian canals, pushing toward the exterior of the bone. After the bone itself is involved, there is subperiosteal new formation, which, if caseation has not occurred, may remain for a considerable time as a semi-solid mass, the adjacent bone and periosteum undergoing thickening and hardening. Sooner or later, and quite rapidly as a rule when caseation has taken place, the periosteum is infected and destroyed, the adjacent soft parts become tubercular, and by one or several tortuous channels following the lines of least resistance the disease reaches the skin, the piercing of which completes the formation of the sinus or sinuses. The walls of such sinus, from its mode of formation, are necessarily tubercular, and its outlet is filled with granulations more or less exuberant, more or less dark-colored, readily bleeding when torn, and at times quite sensitive. A probe being introduced, often with much difficulty because of the flexures of the canal, softened, easily-penetrated bone may be felt, but its presence may escape detection because of the heavy granula-

FIG. 57.



Caries Sicca, resulting in Absorption and Deformity of the Head of the Humerus (Duplay and Reclus).

tion-layer covering it. The difference in the appearance of the external granulations, in the resistance to the probe offered by the bony walls, and in the percussion note elicited by the probe (which is here flat), enables one readily to distinguish caries from necrosis.

When a circumscribed area of bone has broken down and liquefaction of the caseated granulation-tissue in it has taken place, such a collection of fluid has long been spoken of as an abscess; and the same is true of the similar collections between the periosteum and bone and in the overlying soft parts. But, though accumulations of a fluid in appearance much like pus, they are not, properly speaking, abscesses, since true pus is not present (unless it be a fact that at times the bacillus is a pyogenic organism) except when a double or mixed infection has taken place. This is not often the case until a communication with the external air has been established by the spontaneous or operative opening of the sinus. When such an opening has been made, the previously pent-up liquid, with its associated characteristic cheesy, curdy material, escapes, and the continuous development of similar fluid, now probably become purulent, keeps up the discharge. This varies in amount from a few drops to many ounces a day, and lasts indefinitely, with occasional temporary stoppages from blocking up of the canal at one point or another. Its complete arrest can be secured only by destruction of the infected area. This prolonged supuration, by the exhaustion and amyloid visceral changes which it induces, often has much to do with the production of a fatal termination.

In consequence of plugging of the vessels necrosis may take place, the produced sequestrum being often of considerable size. If centrally located in the cancellous tissue, it is surrounded by the infected granulations, and remains until removed by art or until, after a long time, it has broken down, when it may be discharged piecemeal. Often in the extremity of a long bone, because of the arrangement of the vessels which have been plugged by a tubercular embolus or by a thrombus resulting from the mural implantation of tubercle bacilli, it is conical in shape, its base directed toward the articulation; and to its presence may be due rapid involvement of the articulation in the morbid action.

In its earlier stages the progress of tubercular osteitis is ordinarily insidious, often the only **symptoms** of its existence being impaired function of the part, rigidity of the muscles about the neighboring joint, and pain in the affected area. Muscular rigidity, which is a reflex condition and protective in its action (or intended to be such), is of great diagnostic value. It is often the only symptom present, and when observed is deserving of careful consideration, for if no other cause for its existence is apparent, it may be safely assumed that there is something abnormal in the neighboring joint. The pain may be spontaneous or exist only as tenderness on pressure over the diseased spot, but it can always be developed by such pressure. By the thermometer slight increase in the heat of the region may at times, or possibly always, be detected; but a long-recognized peculiarity of this form of inflammation is the absence of any decided elevation of temperature.

The appearance of the overlying skin is generally unchanged, even after infection of the superficial soft parts; though, because of interference with the circulation by pressure, there may be some general discoloration or certain of the veins may become unduly prominent.

Even up to the time of the establishment of a communication with the exterior the symptoms are far from severe, pain, swelling, and impairment of function being present, but no decided constitutional symptoms, and the patient may go about as if in health. But when septic infection has taken place all the local symptoms are aggravated and the constitutional ones become decided.

The only disease with which the affection is then likely to be confounded is protracted osteo-myelitis of pyogenic origin; and this, though more common than is often supposed, is far less frequently met with than tubercular osteitis, and seldom if ever attacks the parts of the skeleton which are so often the seat of the latter disease—the vertebræ, the tarsus and carpus, the upper end of the femur, and the bones of the elbow. It is largely to the prevention of secondary pyogenic disturbances that the present favorable course and prognosis, as compared with those of but a few years ago, are to be attributed. Under any treatment, and especially under inefficient or no treatment, the course of the affection is ordinarily slow, occupying many weeks, it may be months. At any stage it may be arrested spontaneously (1) by removal of the diseased tissue, which is followed by condensation of the surrounding bone with or without cicatricial obliteration of the cavity; or (2) by encapsulation of the infected tissue, which permanently or temporarily protects the part. Very often it is temporary, since recurrence frequently takes place.

The treatment is mechanical, therapeutic, or operative—more frequently the first and second, but often all three methods, are employed either simultaneously or successively.

Mechanical treatment may be held to include all measures adapted to ensure rest of the diseased part, whether by position, immobilization, or the application of fixation apparatus of one sort or another. Rest is of prime importance at any stage of the affection, and is especially valuable in the earliest, when it may be sufficient to bring about arrest of morbid action and more or less complete restoration to health. Simple confinement to bed may be all that is needed, or an immobilizing dressing—*e. g.* the plaster-of-Paris or a properly constructed and applied splint—may be required. Under such treatment, even when there has been much destruction of bone and “cold abscess” has formed, the symptoms may subside. This will be because of absorption and contraction, it may be calcification, of the tubercular masses, condensation taking place in and around the carious area, and functional action being resumed; though, as a rule, there will be more or less impairment, more or less deformity, and an ever-existing danger of a recurrence of the disease.

The therapeutic treatment is general and local. The former consists in the administration of remedies serving to improve nutrition and increase the general strength; and of these cod-liver oil has long been regarded as the most valuable. The local treatment consists in the injection into and around the diseased center of agents calculated to destroy the infecting germs and produce condensation of the surrounding bone and of the uninfected new-formation layers, thus bringing about cicatrization. The remedies of this class that have proved of decided value are the acid phosphate of lime, the chloride of zinc, and iodoform; the latter of which in ethereal solution, or, better, suspended in glycerin (10 per cent.) or in oil (5 to 25 per cent.), has been found of great value as a substitute for the operative removal of the morbid tissue, or employed after it. These solutions are carried down by means of a syringe to and into the diseased area, and injected in small quantity, the injections being repeated every three, seven, or ten days according to circumstances.

Operative treatment consists in the removal of the diseased area by scraping or excision. Amputation is rarely demanded, at least in properly treated cases. Scraping, to be effective, must be thorough, and special care must be taken to clean away the walls of sinuses, to remove infected deposits in the medullary canal of a long bone, and in the foot and hand to leave no part of a softened bone (unless it be perhaps the shell of the os calcis, and this, as a rule, should be taken away). No associated tubercular growth in the tendon

sheaths, the synovial pouches, or the superficial fascia or skin should in any case be allowed to remain.

Ignipuncture by means of the thermo-cautery has been practised by a few surgeons with good effect.

Cases of visceral tuberculosis are generally much benefited, and not seldom cured, by change of climate and altitude, and strumous children often rapidly improve at the seaside. Much good would unquestionably be effected, in the earliest stages especially, by sending patients with chronic bone disease to the coast, the highlands, or the pine woods.

Chronic pyogenic osteitis is almost always the sequel of an acute osteomyelitis that occurred, it may be, many years before, and is the cause of two very different conditions—abscess and overgrowth. It is usually circumscribed, and may be located in the medullary canal, or, much more often, in the cancellous extremity of a long bone, especially in the head of the tibia or the lower end of the femur. It probably is due ordinarily to the newly-aroused activity of long-latent pyogenic organisms left over from an osteomyelitis of childhood; but at times it may be consequent upon a new infection attacking parts less resistant than others because of their having previously been the seat of a septic inflammation.

Rarefaction of the bone takes place in a limited area; condensation goes on around it, though rarely to the extent of producing necrosis, except, it may be, of very limited amount; pus may be almost altogether absent or may be present in considerable quantity and form a *chronic abscess in the interior of the bone* (Pl. XII, Fig. 1). This is especially frequent in the cancellated tissue in the lower end of the femur or in either end of the tibia. The most characteristic symptom is pain, severe, often intense, gnawing or boring, decidedly worse at night, limited to a small space, pressure over which is usually painful, sometimes because of associated periostitis, at times disappearing for weeks or months to reappear again, often without any apparent cause. The bone is frequently decidedly enlarged as the result of its early inflammation or of the hypertrophying effect of the long-continued secondary osteitis.

No treatment is of value except drilling or trephining, by which exit is afforded the pent-up pus, thus taking off the tension. Careful exploration with a long pin or fine drill, carried in various directions through different openings or from the sides of the trephine-well, should be made before deciding that pus is not present. Even if no pus can be found, relief is afforded and the so-called neuralgic condition is removed. Not seldom the pierced bone is abnormally dense. When pus is found it is wise not to be content with simple evacuation of the matter, but to scrape away the softened bone, letting the resulting cavity fill up or contract as it may, or, better, endeavoring to secure its rapid and complete closure by means of a blood-clot or bone-chips, for the success of which attempt complete asepsis is required.

The overgrowth from irritation resulting from this form of osteitis may affect a part or the whole of a bone. At times it is very great, producing marked deformity. Although a chronic process, it is very generally the result of the early osteomyelitis, and the process never having been altogether arrested, it can hardly be considered a part of the phenomena of chronic pyogenic osteitis unless there is joined with it the limited suppuration already considered. Overgrowth in length consequent upon the irritative action of a tubercular osteitis is at times observed, and has occurred after excision, particularly of the lower articulating extremity of the femur, the region of the epiphyseal line not having been removed.

Much more often after both tubercular and septic inflammations, whether



Fig. 1.

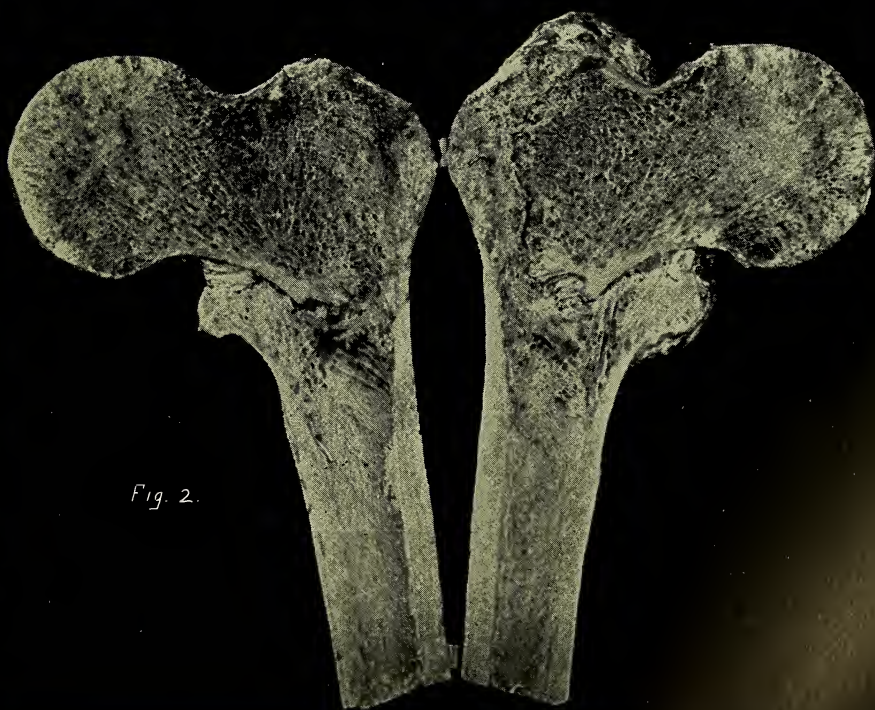


Fig. 2.

an operation has been done or not, there is arrest of development, and as a result shortening, which in children is apt to be progressive up to the time of full maturity.

Atrophy, evidenced by lessened solidity, thickness, or length, or by all of these conditions, is the necessary result of long-continued defective nutrition due to feebleness of the general circulation or to disturbed innervation of the part. It is a common phenomenon of chronic osteitis. It may be temporary, as after fracture, or permanent, as in infantile paralysis and in old age. It causes more or less impairment of the functional value of the bone and strongly predisposes to fracture. No special treatment is of value, unless it be the production of hyperemia, as by frequent applications for a limited time of the Esmarch bandage or by drilling the bone.

RHACHITIS. (SEE CHAPTER XV., p. 81.)

OSTEO-MALACIA (MOLLITIES OSSIIUM, MALACOSTEON).

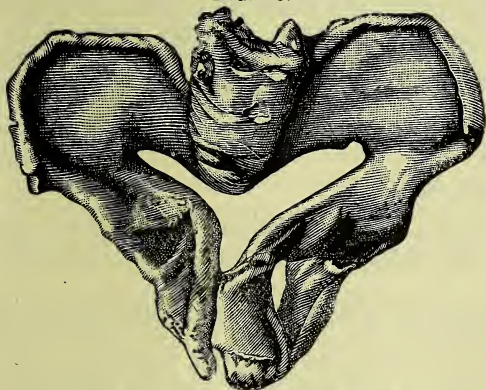
This is a disease of adult life, and is very rarely met with in children or old persons. In the great majority of cases it affects women, chiefly those who are pregnant or who have borne children. It is characterized by progressive softening of the various parts of the skeleton, with resulting deformities (Fig. 58), usually goes on from bad to worse, and after it may be a number of years causes death, chiefly from exhaustion or disease of the lungs. It has been attributed

to the action of many causes, such as defective nutrition, excess of lactic acid, disease of the trophic nerves, ovarian and uterine changes, etc., but the real exciting cause is uncertain.

The bone lesions are great increase of vascularity with resulting hemorrhages, degeneration of the medulla and its ultimate conversion into a pulp resembling splenic tissue, absorption of the lime salts, destruction of the trabeculae, formation of cavities or more rarely tumor-like enlargements, and absorption of the cortical layers. The periosteum is ordinarily thicker and more vascular than normal, and serves as a protective envelope to the broken-down bone. Fracture from muscular action or from slight movement is of frequent occurrence, and deformity to a greater or lesser extent is sure to be produced in other than the mildest cases, the distortion at times becoming excessive and most peculiar.

Until such deformity has occurred, or until at least the softening has advanced so far as to permit of bending of the bone, the diagnosis is difficult and uncertain, since the progress of the disease is for a considerable time an insidious one. The early-developed and persistent pain ordinarily causes the affection to be regarded as rheumatic; but the multiplicity of the painful areas, the sex of the patient, the existence of pregnancy, and the presence of large quantities of the lime salts in the urine, should direct attention to the probable existence of osteo-malacia.

FIG. 58.



Deformed Pelvis from Osteo-malacia (Ollier).

Though commonly for a time not exerting any unfavorable influence upon life, and occasionally ceasing to advance, even being recovered from, though very rarely, its **prognosis** is grave, the disease usually ending fatally. Medical treatment by the use of phosphorus and the phosphates, the lime salts, cod-liver oil, etc. has proved of little or no value. The best possible hygienic surroundings should be secured and the patient kept quiet and free from pain. Proper retentive dressing should be applied to prevent fracture and lessen deformity. Of late in a few cases the ovaries and uterus have been removed with reported decided benefit. When this operation is not done, pregnancy should be prevented, as childbearing exerts a powerful and deleterious influence upon the progress of the disease.

FRAGILITAS OSSIUM.

Abnormal brittleness due to rarefaction and predisposing to the occurrence of fracture upon the infliction of slight violence is sometimes observed in cases of syphilis, of malignant tumors, and of trophic disturbances after injuries of bones and joints necessitating long confinement. It is also seen in the earlier stages of rickets, in general paralysis, and in tabes. But, besides this condition, which is a sequel of disease, there is at times seen a pure and simple fragility, accompanied, so far as can be discovered, by no pathological changes, general or local. This fragilitas ossium is, as a rule, an inherited peculiarity manifesting itself in infants (even in the fetus in utero), in children, and in adolescents, and ceasing to exist when full maturity is reached. Fracture after fracture in one or in several bones or in many parts of the skeleton occurs, presenting the usual symptoms and followed by rapid recovery. As the cause is unknown, nothing can be done further than to protect the individual from injury as much as possible, and to treat the fractures in the usual way.

SYPHILIS OF BONE. (SEE SYPHILIS.)

TUMORS OF BONE.

Bone tumors, like tumors of other parts, are benign or malignant; the former being commonly exostoses, fibromata, or chondromata, the latter sarcomata or carcinomata.

EXOSTOSES are homologous outgrowths differing from hypertrophies in that but a limited part of the circumference of the bones is involved. They are either spontaneous, and appear first during the period of development, or are symptomatic of osteitis, traumatic or non-traumatic, usually syphilitic. They are located chiefly upon the long bones, the skull, or the maxillæ, and are generally cancellous in structure, but at times compact, even of ivory hardness; this is particularly true of the syphilitic exostoses of the skull. When developmental, originating in childhood, though the outgrowths may be found upon any part of the skeleton, even upon many and generally symmetrical parts at the same time (Fig. 59), they are commonly in connection with a long bone near its epiphyseal line. If primarily upon the diaphyseal side of the cartilage of conjunction, they may apparently be carried upward as the shaft elongates, so as ultimately to occupy a level much above the articular extremity. They may be either broad-based or pedunculated, and not seldom the free extremity is covered by a bursa resulting from friction or the separation of a part of the synovial sac in the outgrowth of an originally subsynovial spur. Their growth ceases, as a rule having few exceptions, at or before the twenty-fifth year.

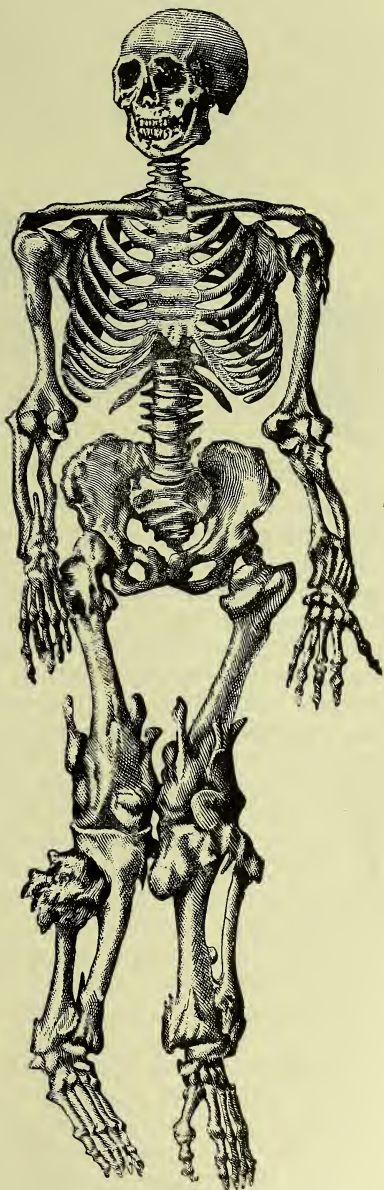
The **diagnosis** is commonly easy, the tumor being hard and fixed and readily felt or seen. Pain is seldom present, and whatever local damage results is from pressure causing atrophy or ulceration of the overlying soft parts (and this is not of common occurrence) or from position interfering with the free use, especially with flexion, of the limb, as in sitting or riding. In a large proportion of cases no serious inconvenience is experienced. When the mass is upon the inner side of the skull (of diploic origin, as a rule), a resulting compression of the brain may give rise to serious cerebral disturbances, but often no appreciable effect is produced, and the existence of the tumor is not discovered until after death.

The only effective **treatment** is operative, removal of the growth, or the breaking of it off, the former being preferable, the latter practicable only when the attachment is by a pedicle. In many cases no treatment is required.

FIBROMATA.—Springing from the periosteum or, much less frequently, central in origin, the fibrous tumors of bone are found generally in connection with the maxillæ and the base of the skull, though they are occasionally located upon the vertebræ, the pelvis, or the long bones. When of long standing they are likely to undergo degeneration, fatty, cystic, or, particularly, calcareous, rarely becoming ossified. Not seldom they are either primarily or secondarily mixed in character—fibro-sarcomata, fibro-chondromata. Their development is slow, and they often cease to enlarge about the time when the skeleton has reached full maturity, after which they may atrophy, or even completely disappear.

If superficially placed, they can generally be readily **diagnosed** by their more or less irregular contour, their firmness but not bony hardness, their evident close connection with bone, and their gradual enlargement. The most common of these growths are the *naso-pharyngeal polyp* and *epulis*, both of which are often decidedly sarcomatous. The former is a disease of adolescence. It originates from the under surface of the sphenoid, fills up the naso-pharynx, pushes into the nasal fossæ and the antrum on one or both sides, and, it may be, outwardly through the sphenopalatine foramen, causing extensive destruction of the bones of the face by pressure. It is dangerous because of the attending hemorrhages, which, as a rule, are profuse and fre-

FIG. 59.



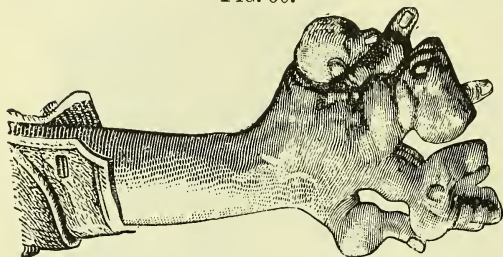
Exostoses of Various Dimensions (Pierret).

quently recurring. The character of the central tumors, which are often cystic, will not be recognized so long as they are surrounded by a bony envelope, and usually is not determined until after their removal.

Treatment.—Extirpation, preferably by enucleation or, when this is not practicable, by excision of the portion of the bone to which the growth is attached, is the proper treatment, though, as has been stated, nature sometimes affords relief through atrophy.

The naso-pharyngeal polyp, if not rapidly growing or often bleeding, may be let alone in the hope of spontaneous disappearance when the patient shall

FIG. 60.



Multiple Chondromata of the Hand (Leo).

have reached the age of twenty-five years or a little more; but in the majority of cases the risk of death from exhaustion consequent upon repeated hemorrhage will forbid such delay. (See Diseases of the Nose.)

CHONDROMATA.—As might be expected, the cartilaginous are the most common of the benign osseous tumors, their chief places of election being the long bones

(in their extremities) and those of the hands and feet (Fig. 60). They may be either peripheral or central, and are not seldom mixed in character, the addition of sarcomatous elements being particularly frequent. Even when microscopical examination has apparently shown them to be pure chondromata they have at times the characteristics of malignant growths, in so far as they recur after removal and by transference of their cell-elements develop visceral disease in the lungs, the liver, or the spleen, especially the first. It is possible, however, that these are examples of mixed tumors, all portions of which had not been subjected to examination. The more nearly their histological structure approaches that of embryonic cartilage, the greater is the liability to secondary manifestations. Traumatism is often an exciting cause. Their growth is generally slow; they frequently become cystic, and always tend toward destructive changes both in their own tissues and in the part in which they are developed. The overlying skin may be unaffected for a long time, but ultimately becomes ulcerated, and a sinus is established communicating with the breaking-down tumor-mass.

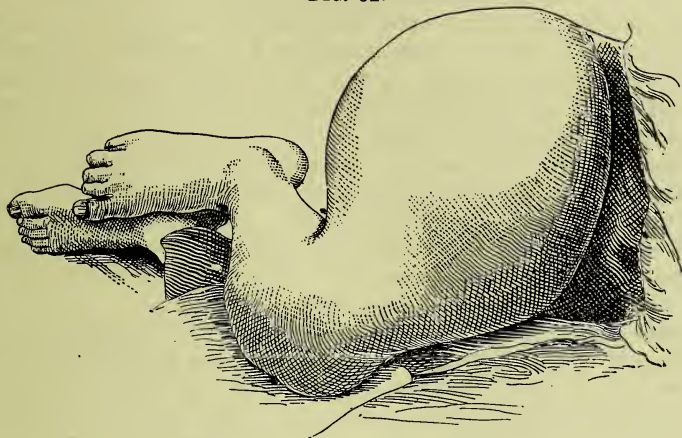
As a rule, they are not painful except when there is involvement of or pressure upon adjacent nerves, either of which is comparatively rare; but by their presence they may interfere with free muscular or articular movements.

If externally located, as upon the hands or feet, their **diagnosis** is easy: when upon the long bones it can be made as a strong probability if regard is had to their position, their slow growth, their elastic firmness, which though decided is not that of bone, and their irregular contour. When softened or cystic their nature may be misunderstood until after incision or puncture. When of mixed sarcomatous character, because of rapid growth and associated constitutional weakness they may be readily mistaken for osteo-sarcomata—a mistake, however, of no practical importance, since the treatment of the two affections is the same. The central growths cannot be recognized until they have reached considerable size, and even then their character will not generally be determined before removal.

The only **treatment** of value is operative, the growth being removed either by itself when it is external and pedunculated, or with a part or the whole of

the bone in which it rests ; in other words, by taking it out and scraping away

FIG. 61.



Osteo-sarcoma of the Femur (original).

the tissue immediately about it, by excision of the diseased portion of the bone, or by amputation.

MALIGNANT TUMORS.—The malignant bone-tumors are either carcinomatous or sarcomatous. The former are comparatively rare and always secondary ; the latter are of frequent occurrence and primary, except when following upon like disease of the adjacent soft parts or upon melanotic sarcoma. Unlike osteo-carcinoma, osteo-sarcoma is a disease of early life, even of infancy and childhood, only a very small proportion of the cases observed occurring in individuals over forty years of age. Histologically, it is of three varieties—round-celled, spindle-celled, and giant-celled ; locally, there are two varieties—central and periosteal. Its malignancy structurally is in inverse proportion to the size of the cells, being greatest in those tumors made up of small round and spindle cells, least in those composed chiefly of giant cells. As respects location, when originally external it progresses more rapidly, has earlier and more frequently secondary visceral manifestations, and is more certainly fatal than when internal. It especially affects the maxillæ and the long bones ; of the latter, those of the lower extremities much oftener than those of the upper. The adjacent ends of the femur and tibia are the most common sites (Fig. 61). Local injury is a strongly predisposing cause.

Osteo-sarcoma affects a neighboring joint comparatively seldom, even at times passing outside the articulation from one bone to another. Often the bone in which it is situated is so weakened by it that spontaneous fracture occurs, and this is occasionally the first indication of its existence. Its rate of growth is variable, though with rare exceptions it is rapid as compared with that of the benign tumors. The size which it may attain is usually not great, but is occasionally enormous. The central growths, which, speaking generally, are giant-celled at the extremities of the long bones, and round- or spindle-celled in their shafts, have for a time an osseous envelope, so thin in some cases as to yield and crepitate on pressure, and later a complete or partial osteo-periosteal capsule. This is not the case with the external growths, the limiting wall of which is periosteum until that membrane has become involved and the disease has pushed through it into the adjacent soft parts. The vascularity of the internal tumors may be so great as to render them pulsatile, apparently

aneurysmal. Without doubt nearly all the reported cases of *aneurysm of bone* have been sarcomata of this character. Hemorrhage into the substance of the tumor is of frequent occurrence, and degenerations, fatty, cystic, and, especially in the periosteal growths, calcareous or to a greater or lesser extent bony, commonly take place. Dissemination, with resulting disease of remote parts, bony or visceral, is chiefly by way of the blood-vessels, affections of the lymphatic glands being infrequently observed. When present it is in large measure only irritative in character.

The chief **symptoms** are pain, which is seldom absent, and at times is intense; swelling, recognized early in the external, but much later in the internal, variety, in shape globular, pear-shaped, or conical near the end of a long bone, spindle-shaped upon the shaft; and increased heat, as determined by the hand or the surface thermometer. There is little or no impairment of the joint motions for a considerable time.

The diseases with which it is most likely to be confounded are rheumatism, because the pain is usually in the neighborhood of a joint, and tubercular disease, because of the location of the swelling. But, taking into consideration the age of the patient, the non-existence of other evidences of any diathetic affection, the absence of joint disease, the firmness of the growth, especially in its earlier stage, the rapidity of its enlargement, and the local temperature-changes, a strongly probable, if not absolute, diagnosis can usually be readily established. Puncture or exploratory incision may be made if necessary. It may also be mistaken for an abscess.

The **treatment** to be effective must be radical, the affected bone being removed, or in an extremity amputation being done at or above the nearest joint rather than in the continuity of the bone, except in cases of central giant-celled growths in the lower end of the bones of the leg or of the femur. When necessity seems to demand disarticulation at the hip, it is very questionable if any operative interference should be resorted to, in view of the risks of the amputation and the almost absolute certainty of an early recurrence of the disease in the stump or viscera. After amputation other than at the hip the probability of reappearance is strong: even in the least malignant variety, the central giant-celled, it occurs in about one patient out of five.

ACTINOMYCOSIS. (SEE p. 133.)

ACROMEGALY.

Enlargement of many of the bones of the skeleton, especially of the face and head, the thorax, the pelvis, and the foot and hand, is a very constant symptom of the peculiar and rare nervous affection first described by Marie in 1886, and by him named *acromegaly*. Such enlargement is a true hypertrophy, new growth taking place under the periosteum and at the cancellous extremities. The bones of the hands and feet and the lower jaw are early and markedly affected.

The more common surgical diseases with which it is likely to be confounded are osteitis deformans and arthritis deformans. From the former it may be differentiated by the earlier age at which it appears, by the almost constant affection of the feet and hands, by the absence of curvature of the long bones, by its being generally symmetrical, and by the ordinarily much greater disease of the face than of the head; from the latter, by the great overgrowth of the hands and feet, and by the absence of the pain, the deformity, and the later ankylosis that are symptomatic of the joint affection.

The disease is of long duration and incurable, and no treatment has any special influence upon the progressive hypertrophy.

CHAPTER III.

FRACTURES.

DEFINITION.—The sudden, forcible destruction of the continuity of a bone, in whole or in part, except when done with a cutting instrument, is called a fracture. A *simple* fracture, in the common use of the term, is one that is not compound (see below); a *spontaneous* fracture is one produced by very slight violence; a *pathological* fracture is one made easy by partial destruction of the bone by disease; an *ununited* fracture is one in which bony union has not yet taken place after the lapse of a period of time that is usually sufficient for repair.

The injury is a common one; it occurs about three times as frequently in males as in females, but the proportion varies at different ages: in infants and between the ages of fifty and seventy years both sexes are about equally affected; in middle life fractures are ten times as frequent in men as in women; and after the age of seventy women are much more frequently affected than men, the commonest fracture then being that of the neck of the femur. The majority of fractures occur in the first and third decades of life, but if the number of people living at the different ages be considered, the greatest relative frequency will be found at about the age of sixty years.

The following table shows the relative frequency of fractures of the different bones. The italics mark bones with more than 10 per cent.:

Fractures Treated in the London Hospital, 1842-77.

	Hospital.	Out-patients.	Total.	Per cent.	Number by Regions.	Per cent.
Skull	730	27	757	1.457	} Head, 2,002. }	3.854
Face	732	513	1245	2.397		
Spine	169	3	172	0.331		
Pelvis	139	3	142	0.273	} Trunk, 9,067. }	17.457
Coccyx	5	10	15	0.028		
Ribs	4784	3477	8261	15.905		
Sternum	45	7	52	0.100	} Upper extremity, }	52.214
Scapula	135	290	425	0.818		
Clavicle	382	7458	7840	15.094		
Arm	1064	3020	4084	7.863	} 27,119. }	26.473
Forearm	709	8731	9440	18.175		
Hand	856	4899	5755	11.080		
Thigh	3072	171	3243	6.243	} Lower extremity, }	26.473
Patella	649	15	664	1.278		
Leg	8067	256	8323	16.024		
Foot	965	555	1520	2.926		
	22,503	29,435	51,938			

VARIETIES.—The varieties of fracture are numerous, the differences depending upon the extent, direction, and seat of the fracture, the number of bones involved, the associated injury of the soft parts, and the character or mode of action of the causative violence. They may be grouped as follows:

1. Incomplete fractures.

- (a) Fissure.
- (b) True incomplete fracture, "green-stick" fracture.
- (c) Depressions.
- (d) Separation of a splinter or of an apophysis.

2. Complete fractures, subdivided, according to—

- (a) *Direction* of the line of fracture, into transverse, oblique, longitudinal, toothed, V-shaped, T-shaped;
- (b) *Seat* of the fracture, into fracture of the shaft, neck, condyle, etc., separation of the epiphysis;
- (c) *Relations to neighboring joints*, into intra-articular, extra-capsular, intra-capsular;
- (d) *Mode of production*, into fractures by direct violence, by indirect violence, by muscular action;
- (e) *Number* of fractures or of bones fractured, or the extent and character of the crushing, into multiple, comminuted, impacted, and fractures with crushing.

3. Compound fractures, including, as a special class, Gunshot fractures.

1. Incomplete Fractures.—This class includes fractures of long bones in which the continuity of the bone has not been entirely lost, and fractures of the flat bones in which the line of fracture does not extend completely across the bone or through its entire thickness.

Fissure, or *fissured fracture*, is a split or crack of limited extent; the most frequent examples are in the bones of the cranium and in connection with complete fractures of other bones.

True incomplete, or “*green-stick*,” fracture is one involving part of the thickness of a long bone, and accompanied by some longitudinal splitting and by a permanent bending of the unbroken portion. Possibly in some cases there is only permanent bending without visible fracture. It occurs in the young, and especially in the clavicle and forearm (Fig. 62). In correcting the deformity, which is best done by bending the bone in the opposite direction, the fracture is frequently made complete.

Depression is the crushing of a portion of the thickness of a bone; it perhaps belongs more properly among “wounds of bone” than among fractures. The class also includes certain rare “fractures by depression,” in which by the forcible bending of a flat bone a fragment is broken from the side toward which the bone is bent, as in isolated fracture of the inner table of the skull: it does not include “depressed fractures of the skull,” in which the entire thickness of the bone is broken.

Separation of a Splinter or of an Apophysis.—Direct violence, as by a bullet or a sword, may break off a piece without completely fracturing the bone, or the violent contraction of a muscle or a strain exerted through a ligament may tear off a scale of bone or an apophysis to which the tendon or ligament is attached.

2. Complete Fractures.—(a) *Subdivided according to the Direction of the Line of Fracture.*—The fracture is termed *transverse* (Fig. 63) if its line is exactly or nearly transverse to the long axis of the bone and regular; *longitudinal* (Fig. 64) if it runs for a considerable distance more or less exactly parallel to the long axis; *oblique* (Fig. 65) if its direction is intermediate between the two preceding. The division is of course somewhat arbitrary. The fracture is termed *toothed* or *dentate* (Fig. 66) if its line is broken by sharp points and depressions, which may constitute a serious obstacle to complete reduction. *V-shaped* fracture of the tibia (Fig. 67) is

FIG. 62.



Partial or Green-stick Fracture of the Radius (Stimson).

characterized by a prominent triangular projection at the lower end of the upper fragment on its inner aspect; its especial importance, other than the occasional difficulty of reduction, is due to a fissure which may extend from the corresponding re-entrant angle on the lower fragment down to the ankle-joint. *T-shaped* fractures are found at the lower end of the humerus and femur, and are sometimes termed *intercondyloid* (Fig. 68): there is a transverse line of fracture above the condyles, and a longitudinal one running from the transverse line downward between the condyles.

(b) *Subdivided according to the Seat of the Fracture.*—The fracture receives a name indicative of the portion of the bone involved in it: thus, fracture of the shaft, of the neck, of a condyle, or of a specific process, as the malleolus, greater tuberosity of the humerus, olecranon. The term *separation of an epiphysis* also indicates that the fracture lies wholly or mainly at the cartilaginous junction between the epiphysis and the shaft; this variety is found, of course, only in persons whose growth is not yet complete; that is, as a rule, only in those who have not yet reached the age of twenty-four or

FIG. 63.



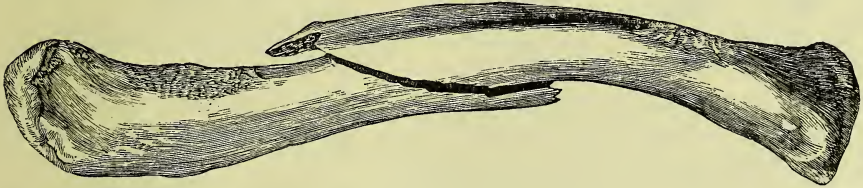
Transverse Fracture of the Femur (Gurte).

FIG. 64.



Longitudinal Fracture of the Tibia (Stimson).

FIG. 65.



Oblique Fracture of the Clavicle (Stimson).

twenty-five years; the date of consolidation of the epiphysis with the shaft varying with the sex, the individual, and the different bones. Separation of the epiphysis is more easily effected than a fracture of the same bone by cross-strain: the periosteum is usually stripped up from the shaft for a considerable distance, varying with the displacement, and remains attached to the epiphysis. The injury is of especial importance because of frequent difficulty of reduction, and because the irritation of the traumatism may lead to premature ossification of the cartilage, with consequent local arrest of growth. This consideration is of most importance at the knee, the upper end of the humerus, and the lower end of the radius and of the ulna, where the principal growth in length of the respective bones occurs.

(c) *Subdivided according to the Relations to Neighboring Joints.*—The term *intra-articular* indicates that the line of fracture extends into a joint—a complication that is important because of the possible inflammation of the joint

and of possible change in the relations of the fragment, either of which may permanently restrict the mobility of the joint. *Intracapsular* and *extra-*

FIG. 66.



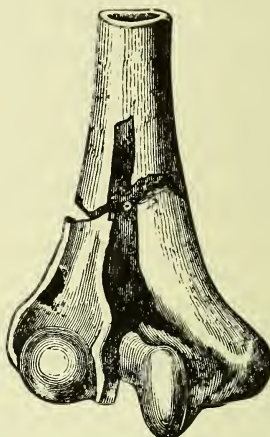
Toothed Fracture of the Femur (Stimson).

FIG. 67.



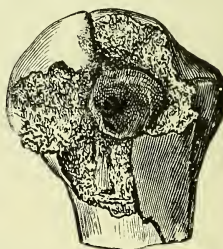
V-shaped Fracture (Stimson).

FIG. 68.



Intercondyloid Fracture of the Humerus (Stimson).

FIG. 69.



Comminuted Gunshot Fracture of the Head of the Humerus, with Impacted Ball (Army Med. Mus.).

capsular are terms used almost solely in connection with fractures of the neck of the femur to indicate the position of the line of fracture within or without the attachment of the capsule to the femur.

(d) *Subdivided according to the Mode of Production.*—Fractures by *direct violence* are those in which the fracture takes place at the point where the blow is received; fractures by *indirect violence* are those in which it takes place at a distance from that point; fractures by *muscular action* are those in which the fracture is produced by the action of the patient's muscles.

(e) *Subdivided according to the Number of Fractures or of Bones Fractured, or to the Extent and Character of the Crushing.*—The term *multiple* indicates two or more separate fractures of a bone, or the fracture of two or more bones other than the tibia and fibula or the radius and ulna of the same limb. A *comminuted* fracture (Figs. 69 to 72) is one accompanied by considerable splintering of the bone, which is broken into several small fragments. An *impacted* fracture is one in which one main fragment is driven into and firmly fixed in the other, which is commonly the expanded spongy end of the bone; the spongy portion into which the other fragment is driven is necessarily more or less crushed thereby, and if the crushing and splintering are such that the enter-

ing piece is not firmly impacted, the fracture is said to be one *with crushing*. Both conditions are more common in advanced life, and, as the crushing amounts to an actual loss of substance, some deformity must persist.

FIG. 70.



Comminuted Perforating Gunshot Fracture of the Head of the Humerus (Army Med. Mus.).

FIG. 71.



Comminuted Fracture of the Lower End of the Radius, palmar aspect (Stimson).

FIG. 72.



Comminuted Fracture of the Neck of the Femur (Stimson).

3. Compound Fractures.—A compound fracture is one which communicates with the exterior through a wound of the overlying soft parts. The latter wound may be directly caused by the same violence that produces the fracture, as in the passage of a wheel of a wagon across the leg, or it may be made from within outward by the forcible projection of the end of one of the fragments through the skin; or a simple fracture may become compound through sloughing of the soft parts occasioned either by bruising inflicted at the time of the accident, or by the pressure of a displaced fragment, or through careless handling, or by the movements of the patient while delirious. The injury is much more serious than a simple fracture, because of the possibility of infection of the wound, with its train of consequences—suppuration, necrosis, failure of union, septicemia, and loss of limb or life. Excluding the hand and foot, compound fractures, according to Gurlt, are most frequent in the leg, being 17.96 per cent. of all compound fractures; those of the forearm form 11.68 per cent.; those of the femur, 7.05 per cent.; those of the humerus, 6.66 per cent. The prognosis is serious in compound fractures by direct violence, because the soft parts are usually so bruised and lacerated that primary union cannot be obtained; whereas in fractures by indirect violence in which the wound of the skin is made by the end of a fragment the prognosis is much better, for the wound is generally small and clean, and if properly treated will usually unite promptly, and the fracture will thus be transformed into a simple one. The diagnosis of the compound character of a fracture, when in any doubt, may be made in case of necessity by careful exploration of the wound with the purified finger, but usually, and especially whenever the wound is small and bruising or laceration is absent or slight, it is better to abstain from completing the diagnosis by any measures that may increase the chance of infection, and to direct all efforts to obtaining the prompt disinfection and closure of the wound.

Gunshot fractures (Figs. 69, 70, 73) constitute an especially severe form of compound fractures because of the usually extensive comminution and fissuring of the bone, the bruising of the soft parts along the track of the bullet, and the

FIG. 73.



Gunshot Fracture of the Humerus (Army Med. Mus.).

greater frequency of associated injury of important blood-vessels and nerves. A small bullet may make a clean perforation with but little splintering; a large one literally smashes the bone at the point of contact and produces fissures that may extend to a great distance; the bullet may pass completely through the bone or may lodge in it. In fractures produced by a charge of shot the associated laceration of the soft parts is usually the dominant feature of the case. Amputation and excision have been the rule in the past, and discussion has turned mainly on the respective merits of primary and secondary operations. Antiseptic surgery has not yet been put to a sufficient test in war to determine fully the extent to which it will modify previous rules of treatment, but it will undoubtedly avail to save a much larger proportion of limbs and lives. In civil practice it has been clearly shown that suppuration and infection can be prevented in a large proportion of bullet wounds, and that the removal of the bullet is not a necessary preliminary to successful treatment. The guiding principle is to abstain as far as possible from exploration of the wound with probe or finger, to disinfect it thoroughly by antiseptic washing, and to seek its prompt healing under a single dressing combined with measures to immobilize the fracture: this failing, counter-openings, drainage, and irrigation to meet the needs created by suppuration.

DISPLACEMENTS.—The following six classes comprise the common changes in the relations of the principal fragments,—the name indicating, in all but the fifth, the direction in which the change has taken place: 1, transverse displacement; 2, angular; 3, rotary; 4, overriding; 5, impaction or crushing; 6, direct longitudinal separation. Commonly two or more are associated in any given case.

Transverse or lateral displacement may take place in any direction at right angles to the long axis of the bone, and may be complete or partial. In angular displacement one fragment deviates obliquely from the line that represents the normal relation of its long axis to that of the other fragment. In rotary displacement one fragment has been separately turned about its long axis. In overriding, the upper and lower ends of the bone are brought nearer to each other by the passage of the broken surfaces past each other: it is common in oblique fractures, and is necessarily associated with some transverse displacement, and usually with angular displacement. In impaction or crushing the bone is shortened by the forcing of one fragment into the other, or in spongy bones an angular displacement is effected by the crushing of the bone at the angle on the side toward which it is bent. Direct longitudinal separation is most commonly seen after fracture of the patella and olecranon, and is then due to the contraction of the attached muscle; but it may be produced after fracture of the humerus by the unsupported weight of the lower part of the arm and the forearm.

Displacement may be caused at the time of the accident by the force which produces the fracture, or subsequently by the action of gravity or of the attached muscles upon the fragments. The tonicity of the muscles and

their contraction when excited by pain habitually tend to produce angular displacement, and overriding when the character of the displacement permits it. (See Figs. 63 and 65.)

ETIOLOGY.—1. Predisposing Causes.—These are of two kinds, normal and pathological. Normal predisposing causes are found in the shape, structure, and functions of the different bones, with such modifications as are produced by advancing years. A long bone is exposed by its very length, as well as by the uses which that length subserves, to fracture by indirect violence, by cross-strain, or by torsion; length is to that extent a predisposing cause. A short bone or the spongy end of a long one is fitted by its texture and its breadth to receive and transmit violence with the minimum of damage to the bone with which it is in contact, but the same texture and breadth expose it to easy crushing and splintering when the violence is unusually great or is abnormally directed. To that extent its spongy texture is a predisposing cause. The normal curves found in so many long bones, and the transformation of the segments of a limb into the equivalent of a single sharply-bent bone by the rigidity of the strongly-contracted muscles, tend to diminish the risk of dangerous violence to the trunk and viscera in a fall, but in thus protecting vital organs they become themselves more exposed to fracture.

As age advances the bones become more fragile by rarefaction of their spongy and compact tissue: the change is an actual diminution of the amount of bone-tissue in the bone, not an alteration in the proportions of the different elements that compose that tissue; there appears to be no increase in the amount of the earthy matter, either actually or relatively. As an habitual incident of advanced age this senile atrophy may be deemed a normal predisposing cause, but when it appears prematurely or in an excessive degree it is pathological. Such premature and excessive fragility, dependent upon causes that are not always understood, may be inherited or acquired. Cases have been reported in which successive generations have shown remarkable liability to fracture from infancy; in one instance a child received fourteen fractures before he was thirteen years old. In other cases some or all of the children of a family have shown it, the parents being free from it; thus, a girl suffered thirty-one fractures between the ages of three and fourteen years, and her sister nine between the ages of eight months and six years, while two brothers and a third sister showed no such predisposition. The cases are much more numerous in which a similar liability to fracture has developed later in life, the bones breaking under the slightest violence or muscular effort. Such fractures commonly unite within the usual time. Post-mortem examination has shown great thinning and rarefaction of the bone. Fragility may be developed by disuse, as in limbs that have remained dislocated, and in conjunction with certain diseases of the nerve-centers. Rhachitis is a predisposing cause in childhood, through the incomplete development of the bone-tissue to which it leads, the bone remaining spongy instead of developing a firm, compact, cylindrical formation. Syphilis, cancer and other tumors, and caries may predispose to fracture by destroying a portion of the bone. Rheumatism has been alleged to be a predisposing cause, because some patients have suffered aching pain in certain bones for some time before they have broken under slight violence or, more commonly, by muscular action. The widespread disposition to call such pains "rheumatic" accounts for the supposed connection. Fracture of the patella is not infrequently preceded by such pain, which seems possibly to be evidence of previous slight injury or partial fracture.

2. Immediate or Determining Causes of Fracture.—The immediate cause of a fracture may be violence received at some point upon the surface of the

body, or exerted upon the bone that is broken by the muscles that are attached directly or indirectly to it. The former are termed *fractures by external violence*, the latter *fractures by muscular action*. The latter class does not include cases in which, while the causative force originates in the contraction of the patient's muscles, an additional and essential factor is created by external resistance, as in the breaking of the leg by a sudden turn or forward movement of the body while the foot is held fast, or of the arm by striking it against some object.

Fractures by external violence are divided into two classes which have important clinical differences—those by *direct* and those by *indirect* violence. Fractures by *direct violence* are those in which the bone is broken at a point corresponding to that upon the surface where the blow is received; fractures by *indirect violence* are those in which the bone is broken at a distance from the point where the blow is received. An important clinical difference is that in the former the overlying soft parts are contused, and often to such an extent that the fracture is or soon becomes compound, and primary union of the wound is difficult or impossible; in fractures by indirect violence the injury to the soft parts is habitually less, and if the fracture is compound the edges of the wound in the skin are not so contused that primary union is difficult to obtain.

Fractures by muscular action are most common at the patella, the bone being broken by the powerful contraction of the quadriceps; in other cases the muscles produce the fracture by exaggerating the normal curve of the bone, as the humerus or femur in spasmodic or voluntary contraction, or the ribs in coughing, or the sternum in straining during labor; or by tearing off an apophysis to which the muscle is attached, as the coracoid process or the posterior end of the calcaneum; and in others by creating in portions of the body conditions of momentum which act in the same manner as external violence, as in fracture of the humerus by throwing a stone, of the femur by kicking at, but not striking, an object, of the neck in throwing the head back.

SYMPTOMS AND DIAGNOSIS.—Before proceeding to the examination of the injured region inquiry should be made into the circumstances connected with the injury, and the question should always be asked if the part has been previously injured, in order that an old deformity may not be mistaken for a recent one.

1. OBJECTIVE SYMPTOMS.—Deformity.—Under this term are included changes in the appearance of the injured region, in the dimensions of the limb, and in the relations of different bones or parts of bones to one another. Swelling occurs promptly, and is often associated with heat and redness. Ecchymoses appear rather tardily in fractures by indirect violence, and usually at some distance from the seat of fracture. Large blebs, containing a liquid that is at first yellow and later bloody, sometimes appear during the first or second day, especially in fractures of the leg and forearm. Most of the various displacements that have been above described may be readily recognized by the eye or finger when the bone is not thickly covered by soft parts; angular displacement is often shown by a change in the direction of the segments of the limb; and overriding or impaction is demonstrated by measurement of the length of the bone or of the limb. When the two ends of a bone can be readily recognized, as those of the forearm or leg, its length can be directly measured, but in fractures of the femur or the humerus it is necessary to measure from points on other bones, the ilium and the acromion respectively; and then it is essential to accuracy that the injured limb and its fellow with which the comparison is made should be symmetrically placed with reference to the bone on which one of the fixed points is taken. Two other possible sources of error in measuring

should always be borne in mind: one is previous injury or disease that may have affected the length of either limb; the other is the normal inequality in the length of the limbs which exists in many people; this rarely amounts to more than a quarter of an inch, although it may reach an inch or more, and its existence is usually unknown to the individual until revealed by measurement.

By **abnormal mobility** after fracture is meant the independent mobility of the fragments of a fractured bone which is normally one unbroken structure, or the mobility of a joint in an abnormal direction or to an abnormal extent in consequence of the fracture of a portion of the end of one of the bones that constitute it. It is usually present and recognizable with great ease when the fracture occupies the shaft of a long bone, but it may be absent or unrecognizable when the fracture is close to the end of the bone. It is habitually accompanied by a sensation of grating which may be heard or felt, and which is technically known as **crepitus**. This is produced by the rubbing of the broken surfaces upon each other. Abnormal mobility and crepitus are pathognomonic of fracture, but it must be remembered that in not a few fractures either or both are absent or unrecognizable, and that failure to obtain them is not a proof of the non-existence of a fracture. Furthermore, the manipulations necessary to recognize them are, in some cases, actually harmful, and the diagnosis must be made on other symptoms.

2. **SUBJECTIVE SYMPTOMS.**—These are chiefly diminution or loss of function, and pain. The history of the case is also of much value. The extent of the interference with function depends upon the importance of the broken bone to that function, the relations of the fragments to each other, and pain or fear of pain. After fracture of the thigh or leg the patient is, as a rule, entirely unable to walk or to lift the limb from the bed when he is recumbent, but, on the one hand, the disability may be much less, and, on the other, equal disability may be caused by a simple contusion. Pain, either spontaneous or aroused by pressure or movement, is a constant accompaniment of fracture, and when limited to a small area and invariably aroused by pressure with the end of the finger or by slight movements communicated to the limb, is a valuable sign of fracture—one upon which a diagnosis of fracture in certain regions can be safely made when the history of the accident indicates that such a fracture may have been produced.

The examination should be made quietly and systematically; movements communicated to the bone in the search for abnormal mobility and crepitus should be slight and gentle, and if the muscles are spasmodically contracted, or the patient timid, or the injury obscure and of doubtful character in the neighborhood of a joint, an anesthetic should be employed.

REPAIR OF FRACTURE.—In simple fractures there is at first some rise of temperature, the limb swells promptly, blebs sometimes appear on the surface, ecchymoses and yellow discoloration of the skin extend to a considerable distance: then the swelling subsides, and a firm ovoid mass, which is tender on pressure, can be felt about the seat of fracture. This gradually grows smaller and harder and the abnormal mobility diminishes. After a lapse of time, the length of which varies with many conditions, abnormal mobility entirely disappears and the fracture is said to be united. The length of time requisite for such union is greatest, as a rule, when the fracture is of the shaft of the femur in an adult, in which case it is usually from six to eight weeks; it is least at the spongy ends of the bones, less in children than in adults, and greater when there is much permanent displacement. After final healing the limb slowly regains its usefulness, the muscles fill out, and the skin becomes soft, but for

many weeks the limb may show a tendency to venous congestion and œdema and the movements of its joints be restricted. In compound fractures that do not promptly become simple, if left to itself the wound suppurates, the pus burrows, neighboring abscesses form, union of the fracture is delayed, and even after it has taken place the wound may be kept open for weeks or months by suppuration about a loose or attached necrotic fragment.

The lesions of a fracture comprise the breaking of the bone into two or more fragments, the tearing of the periosteum, and the laceration of the soft parts. A portion of the periosteum habitually remains untorn, although stripped up for a greater or less distance from one or both fragments, and constitutes a remaining bond, a "periosteal bridge," between the fragments. This plays an important part in the repair of the fracture. The periosteum thickens, and on its under surface appears a layer, at first soft, then cartilaginous, which extends along the periosteal bridge from one fragment to the other, as well as under the periosteum that remains adherent; the portion belonging to the periosteal bridge thickens and spreads between the fragments, and ultimately becomes bony and continuous with the granulations coming from the bone itself. This is the only portion of the callus which passes through a cartilaginous stage. The bone becomes rarefied by enlargement of its Haversian canals, and at its broken edge and on the adjoining surface of the medullary canal granulations appear which increase until they meet those coming from the periosteal bridge and from the other fragments, and fill the space between them, and also usually the medullary canal at the seat of fracture.

These granulations become fibrous and finally bony, and thus is formed the **callus**, which, when complete, fills the gap between the fragments, occupies the medullary canal for some distance, and forms a layer on the outside of the bone for a greater or less distance above and below the fracture. As time passes this callus becomes smaller, and the portion that forms the medullary plug may entirely disappear, and thus the continuity of this canal may be restored. If there is much permanent displacement, or if the fragments are not effectually immobilized during repair, the callus will be larger than under other circumstances, and tendons and fibrous tissue attached to the bone near the fracture may be included in the area of irritation and become ossified. Such ossification at a distance may be destructive to the functions of the limb, as when a fracture is in the neighborhood of a joint, or in the case of the radius and ulna, which may become united to each other with consequent loss of rotation of the forearm. Sometimes a neighboring joint becomes entirely obliterated by bony union of its opposing articular surfaces.

Fragments that are entirely detached, even from the periosteum, may regain their vital connection with the body, apparently by the growth of new vessels into their Haversian canals, and again form an integral part of the bone. Others may remain imbedded in the callus, but without vascular connection, and be tolerated for years: under the influence of various causes they may ultimately lead to suppuration.

Occasionally the evolution of the callus is arrested at the fibrous stage, and union is then said to have failed or to be fibrous. Fibrous union may be so close and firm or so well supplemented by the interlocking of the different parts of the callus that have ossified that the limb is very useful. The common causes of fibrous union are separation of the fragments and insufficient immobilization.

COMPLICATIONS AND LATE CONSEQUENCES.—With the healing of the fracture the limb is not immediately restored to a normal condition; it is

shrunken, the skin is dry and rough, the limb swells on use, and its joints are more or less stiff.

Most of these abnormal conditions gradually disappear, but in the aged the limb may long remain sensitive to free use and to changes in the weather, and the **stiffness of the joints** may persist. The latter is due in great part to the inflammatory conditions that have existed in and about the joint as a direct consequence of the fracture, or to the implication of neighboring tendons; but in the joints of the *fingers* it may be due to the immobilization, and is much more likely to arise when the fingers have been kept extended. It has been clearly shown that prolonged immobilization of the *large* joints, *per se*, is not a cause of permanent stiffness, and that passive motion of the joint is not necessary, or even desirable, during treatment of the fracture, to prevent it. If the joint is inflamed, the best means of reducing the inflammation and restricting its results is to keep the joint at rest. Persistent swelling of the limb, especially of the leg, is apparently the result of interference with the venous flow, and may be the cause of or be associated with much trouble and annoyance, especially if the callus is large and adherent to the skin. The nutrition of the limb is interfered with, persistent ulcers form, and eczema torments the patient.

Persistent paralysis of one or more groups of muscles may appear as a consequence of injury of a nerve-trunk at the time of the accident, or of its later inclusion in the callus; the latter has been observed only in the musculo-spinal nerve after fracture of the shaft of the humerus.

Exuberant and Painful Callus—Excessive size of the callus may cause trouble by interference with the circulation, or by stretching the skin, or by pressure on a nerve. The second cause is not uncommon in the leg, and may call for relief by chiselling away the bone. Pressure upon a nerve may occur at any point where a nerve lies in close proximity to the bone, as in the case of the ulnar nerve at the back of the elbow. Persistent pain in the callus may be due to an inflammatory process, as suppuration about a sequestrum, or to a non-inflammatory condition of unknown character which has been termed osteo-neuralgia; occasionally it has been traced to inclusion of a nerve-filament in cicatricial tissue.

The other complications to be described are those that arise during the earlier period of the case and put the patient's life in danger. Most of them are extremely rare.

Embolism.—The thrombus of the small veins that have been torn may extend to the large ones, and a portion may be detached and lodge in the heart or in the pulmonary artery. For the symptoms and course the reader is referred to the section on Thrombus and Embolism (p. 57). **Fat embolism** (see p. 92) has been recently recognized as an occasional cause of death in the first few days after the receipt of a fracture. Liquid fat set free by the crushing of the marrow passes into the open veins and lodges in the pulmonary capillaries. The symptoms are not constant or characteristic; there may be sudden dyspnea with subsequent oedema of the lungs, or there may be only prostration without dyspnea, but with cyanosis, quick, feeble pulse, and coarse râles. In some cases the symptoms resemble those of shock, from which the affection is to be distinguished by its antecedent period of comparative well-being.

Rupture of a large artery may be caused by stretching or by perforation; the blood escapes freely until the resistance of the soft parts checks it, and then a traumatic aneurysm forms. The general practice is to postpone active treatment of the injury of the artery, if possible, until repair of the

fracture has taken place. The bruising of an artery may be followed within a few hours by the formation of an obstructing thrombus within it.

Gangrene may be the result of direct bruising of the soft parts or of interference with the circulation in the large vessels arising from their injury or compression by a displaced fragment or from the pressure of a bandage. It may be partial or may involve the limb as far up as the seat of the fracture.

Septicemia and **pyemia** occur, as a rule, only after compound fracture, and, if the fracture is treated antiseptically, are very rare.

Tetanus is a rare complication, and is seen most frequently after compound fracture.

Delirium tremens is a frequent complication of fracture in adults addicted to the use of alcohol. It is, as a rule, milder than the delirium tremens that develops without an injury. Warning of its approach is given by agitation and insomnia, and it can often be aborted or arrested by the vigorous use of sedatives. The outbreak seems generally to be due to the cutting off of the daily ration of alcohol, which is usually the result of the accident and the admission to a hospital; and this indicates the advisability of continuing moderate stimulation for the first week or two in patients who are habitual drinkers.

Treatment.—By the reduction or setting of a fracture is meant the restoration of the displaced fragments to their normal position, or at least to that in which it is desired that reunion shall take place. The manipulations commonly employed are traction upon the lower fragment to correct overriding or angular displacement, and direct pressure to correct lateral displacement or longitudinal separation. Reduction should be made as completely and as promptly as circumstances will permit, having regard to the condition of the patient and of the limb. If there are severe associated injuries and the shock is great, it is well to wait for reaction, and meanwhile to immobilize the parts in partial reduction with simple dressings; if the limb is greatly swollen it may be impossible to restore it to its full length without causing dangerous pressure. An anesthetic may be required to overcome the opposition of the muscles; and in the case of a fracture near to or involving a joint anesthesia is doubly valuable, both to recognize the details of the fracture and to facilitate the complete and accurate readjustment of the parts.

Usually no greater force is required to effect reduction than that which can be exerted by the hands of the surgeon or of an assistant, but in some impacted fractures the fragments are so firmly wedged together or one is so small or inaccessible that reduction cannot be made. Traction is made by grasping the lower segment of the limb and pulling firmly and steadily upon it; coaptation is made by the direct pressure of the fingers and thumbs upon the fragments close to the fracture; angular displacement in "green-stick" fracture, and in others where it is not combined with overriding, is corrected without traction by forcibly bending the bone back into line. If there is so much crushing of the spongy end of a bone that the restoration of the fragments to their normal position would leave an important gap between them, the restoration should not be made, but the fragments should be left in contact.

Permanent dressings have for their main object the prevention of displacement of the fragments by the action of the muscles or by external forces, especially gravity. The means by which this object is to be attained vary greatly in the different fractures, but in most cases they consist of some form of lateral support, often combined with permanent traction upon the lower segment of the limb. Dressings applied circularly about a limb expose it to the danger of constriction, and consequent gangrene, if swelling should occur after the dressing has been applied, and therefore, as a general rule, such should not

be used during the first few days, or if used should be frequently inspected. If applied while the limb is swollen, they are liable to be made too loose by the subsidence of the swelling and to need renewal or readjustment. As a general rule, a roller bandage should not be applied to the limb under the splints; it will rarely do good, and may do great harm. Another rule is to include in the dressings the joints at either end of the broken bone.

The simplest form of lateral support is that furnished by wooden **splints**: they should be longer than the broken bone, of such breadth and thickness that they will not yield under the weight of the limb, and should be thickly padded with cotton to fit the contour of the limb or placed over detached cushions made for the purpose; they are made fast, one on each side, with strips of adhesive plaster, straps, or a roller bandage; they should be so wide that the enveloping bands will not circularly constrict the limb. Projecting bony points should be protected by thick padding *about* them, not *on* them. Carved wooden splints made to fit average limbs rarely have advantages commensurate with their cost. Gooch's flexible wooden splints (Fig. 74) made of thin strips of wood fastened close together on a muslin backing are convenient in some cases. They can be easily made by fastening the strips upon a sheet of adhesive plaster.

Fracture-boxes are essentially a combination of lateral and posterior splints, and are used only for fractures of the leg. They consist of a long rectangular piece of wood with two hinged sides and a movable foot-piece. The central posterior piece is first well covered with cotton, oakum, or bran; the limb is laid upon it and the foot bound to the foot-piece; then the sides are turned up, with interposed padding, and bound to each other across the front of the leg by cords or bands running through holes made for the purpose. To avoid troublesome pressure upon the heel the foot may be suspended by a long and not too narrow strip of adhesive plaster running from the middle of the calf along the back of the leg to the heel, and up past the sole of the foot to the top of the foot-piece. After application of a fracture-box or any equivalent apparatus suspension from a horizontal bar held up by two vertical side-pieces is often of great advantage.

Volkmann's splint is a convenient substitute for a fracture-box, and very useful as a temporary dressing for fractures of the leg. It is a shallow gutter of tin with a foot-piece and a movable support by which the lower end is held at a convenient height above the bed.

Wire gauze is a convenient dressing for fractures, since it is flexible enough to adapt itself to the varying dimensions of the limb under the pressure of a roller bandage, and can be bent to fit the elbow or ankle by cutting it partly through on the sides.

Moulded splints can be made of any material that can be temporarily softened so as to be fitted to the limb and will then harden and retain the shape that has been given to it. For the lighter splints plaster of Paris, pasteboard, leather, felt, and gutta-percha are used; for the heavier ones plaster of Paris is the most convenient. To make a *plaster-of-Paris splint* (Fig. 75) the surgeon cuts strips of gauze, coarse muslin, or thin blanketing of the desired length and width, and soaks them with freshly-prepared plaster of the consistency of thick cream; he then squeezes out the superfluous water, covers the limb thickly with vaseline, applies the splint, and secures and at the same time moulds it to the limb with a roller bandage; after it has hardened he removes the roller and secures the splint by circular turns at two or three points. If sharp angles are

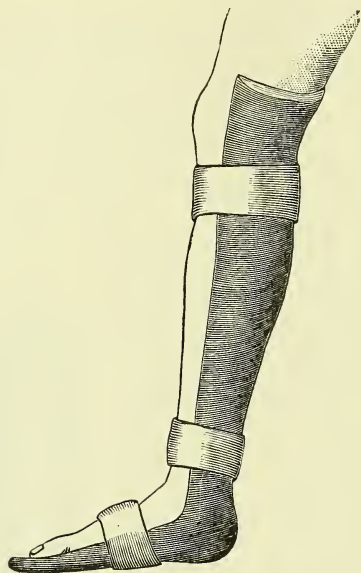
FIG. 74.



Gooch's
Flexible
Wooden
Splint
(Stimson).

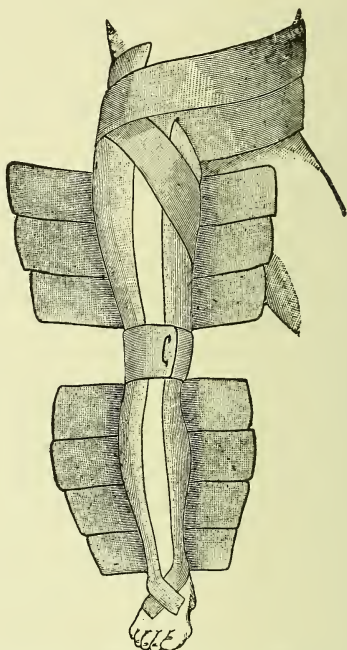
made, as at the elbow or ankle, the fit can be improved by notching the splint while it is still soft and slipping one edge of the cut under the other. Such

FIG. 75.



Posterior Plaster-of-Paris Splint or Gutter
(Stimson).

FIG. 76.



Plaster-of-Paris Dressing, made of coarse sackcloth
(Esmarch).

splints are very useful in the treatment of fractures of the leg, but are not strong enough for those of the femur; they may be applied while the injury is still recent, and permit inspection without having to be removed.

The *plaster-of-Paris bandage* for complete encasement of the limb is most conveniently made by using gauze rollers that have been prepared by thorough filling with dry plaster. The limb is enveloped in cotton or other soft material, and then the prepared roller bandages, after having been thoroughly wet, are applied in the usual manner. Or strips of some coarse material soaked in plaster cream may be applied, as shown in Fig. 76. They can be fenestrated at any point by cutting out a piece after the plaster has hardened, or may be "interrupted," the two segments being attached to each other by iron bands  set into the dressing. Similar dressings can be made with silicate of soda, dextrin, starch, or glue.

In order that such a dressing shall prevent shortening of the limb within it, it is essential that it should have a bearing against bony prominences or a flexed segment of the limb above and below the fracture: such points of counter-pressure are easily found in the leg and forearm, but with difficulty in fractures of the arm and thigh.

If any splint, or still more any circular encasement, has been applied shortly after the receipt of the injury, it should be inspected at intervals of a few hours for the first day or two, with the view of loosening it at once if it should prove to have been too tightly applied or if it should have become too tight in consequence of the subsequent inflammatory swelling of the limb. The patient and his friends should be warned of the possibility of strangula-

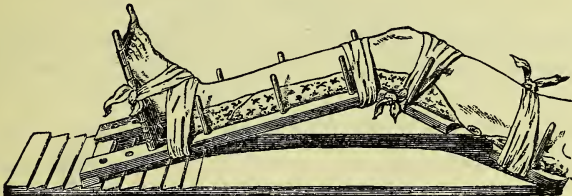
tion of the limb, and instructed to watch the color and temperature of its distal portion, which, for this reason, should always be left uncovered by the dressing. It is almost always advisable to use during the first few days splints that can be easily loosened or which will permit swelling to take place without causing dangerous constriction; and then after the swelling has notably diminished to readjust the splints or apply a permanent immovable dressing.

In fracture of the leg a plaster splint can be so made that the patient can walk about on it after the first week. A layer of cotton two inches thick is bound under the sole by a few turns of the bandage, and then a plaster sole, made of eight or ten layers of gauze, added and firmly included in the dressing. The leg portion of the splint should be applied directly to the skin, or with only a thin layer of cotton interposed, and should be snugly moulded to fit the expanded upper portion of the tibia and fibula. If the fracture is above the lower third, the dressing should be carried up above the knee. Patients with fracture of the thigh can also be enabled to walk about by supplying them with a plaster dressing and adding an apparatus like the splints used in cases of hip disease. The advantages claimed for this "ambulatory method" are the avoidance of the risks of confinement to bed, less atrophy of the muscles and stiffness of joints, and shorter convalescence.

The methods for applying continuous traction to the lower segment of the broken limb include the double inclined plane, suspension, Buck's extension, and india-rubber bands in combination with side-splints.

The *double inclined plane* (Fig. 77) is sometimes used in fractures of the

FIG. 77.



Esmarch's Double Inclined Plane (Esmarch and Kowalzig).

thigh; it is made of a short thigh- and a long leg-piece hinged together at one knee, and hinged at the upper end of the thigh-piece to a long underlying third piece, as shown in the figure. Traction is made by the weight of the pelvis as it sinks in the bed.

In *Buck's extension*, a very popular method of treating fractures of the femur, the traction is effected by a weight attached to the leg by a cord which runs over a pulley at the foot of the bed. This attachment is made by adhesive plaster, the introduction of which constituted an immense improvement in the treatment of these fractures. It is applied as follows: A strip of stout adhesive plaster, four or five inches wide and long enough to reach from well above the knee loosely around the sole of the foot and back to the same height above

FIG. 78.



Adhesive Plaster cut for Buck's Extension (Stimson).

the knee, is cut as shown in Fig. 78; a piece of wood five by three inches and perforated at its center is placed at the middle of the strip, the edges of

which are turned down over it and over each other, as shown in Fig. 79; a stout cord is then passed through the hole in the piece of wood and its end

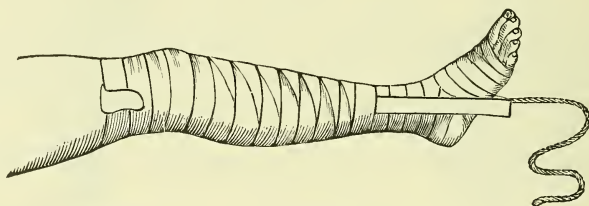
FIG. 79.



Adhesive Plaster folded for Buck's Extension (Stimson).

is tied in a knot. A roller bandage is applied to the foot and the lower third of the leg; the adhesive plaster is then applied to the sides of the leg and thigh above it, and secured by continuing the bandage upward (Fig. 80). The cord is then carried over a pulley at the foot of the bed and attached to the weight, ten to twenty pounds according to circumstances. The foot of the bed must be raised, to obtain the counter-extension by the weight of the body. Outward rotation is prevented by securing the limb to a long

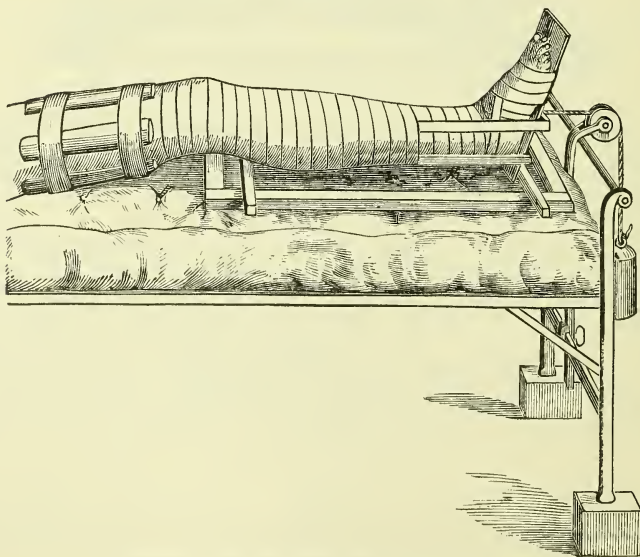
FIG. 80.



Adhesive Plaster applied for Extension (Stimson).

side-splint having a cross-piece at its lower end that rests on the bed, or, better, by placing the leg on a Volkmann's sliding rest (Fig. 81) which

FIG. 81.

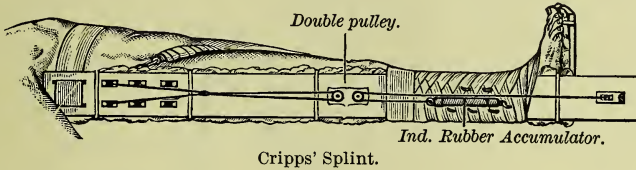


Volkmann's Sliding Rest for Fractures of the Thigh.

is composed of two side-pieces about two feet long and eight inches apart, on which rest by two cross-pieces a posterior splint and foot-piece, to which the

foot and leg are attached in the usual manner. Instead of the weight and pulley an india-rubber cord may be used. The attachment to the limb is made by adhesive plaster. Fig. 82 shows such an apparatus in use for fractures of the

FIG. 82.

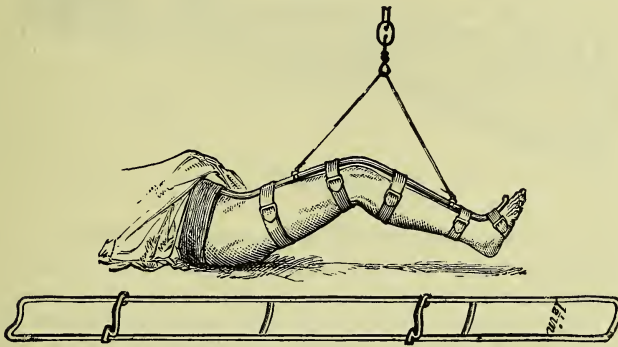


Cripps' Splint.

thigh. Vertical suspension of the limb by a rubber cord attached to the limb by adhesive plaster is sometimes useful in fractures of the humerus close to the elbow, and is common in the treatment of fractures of the thigh in young children.

Nathan R. Smith's anterior splint (Fig. 83) acts like the double inclined

FIG. 83.



Nathan R. Smith's Anterior Splint.

plane when the suspension is vertical, and like Buck's extension when it is oblique.

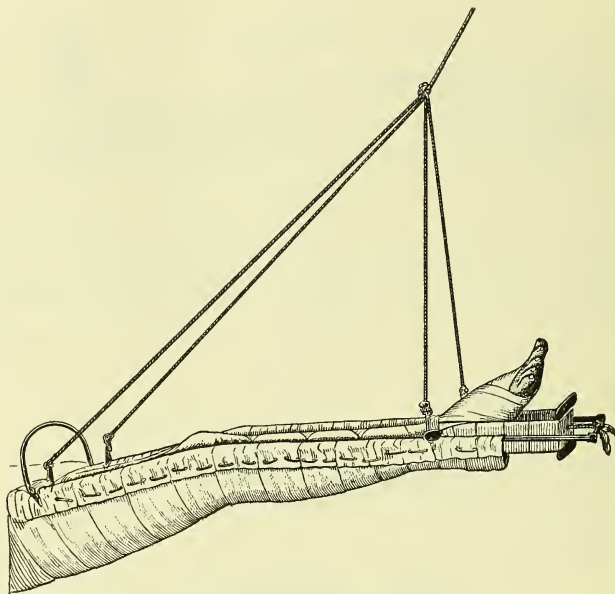
Hodgen's splint (Fig. 84) acts on the principle of Buck's extension, and has the additional advantages of slight flexion of the knee and of greater facility in moving the patient in bed. It consists of two lateral iron rods connected by a straight cross-piece at the lower end and a curved one at the upper end. Lateral strips of adhesive plaster are applied to the limb, as in Buck's extension, and their projecting ends made fast to the foot-piece. Five or six narrow compresses or pieces of bandage are run across from one rod to the other beneath the limb, and so adjusted as to give uniform support to it when the apparatus is raised from the bed. The point of attachment of the supporting cord should be at least four feet above the bed, and the cord should be inclined about ten degrees from the vertical (toward the foot of the bed, of course). The greater the inclination the greater the traction.

Treatment of Compound Fractures.—One of the chief advances made possible by antiseptic surgery is in the results now achieved in the treatment of compound fractures. Formerly they were excessively dangerous accidents from septic infection; now this danger has been almost entirely eliminated. But all depends on the proper and thoroughly antiseptic character of the first dressing.

This dressing of a compound fracture is often equivalent to a major

surgical operation, requiring the aid of anesthesia, the use of instruments, and the protection of antiseptic measures. After anesthetization, the surface of the limb

FIG. 84.



Hodgen's Splint (original).

all about the wound is thoroughly washed, shaved, and purified. By "purifying" is meant securing the most thorough antiseptic cleansing of the entire interior as well as exterior of the wound in every nook and corner of possible infection. This is a *sine quâ non*. If covered with machinery grease, etc., thorough rubbing with sweet oil or with turpentine and alcohol before scrubbing with soap and water greatly facilitates the proper cleansing. Blood-clots and loose splinters are removed, wounded vessels tied, divided nerves and tendons sutured, the ends of the fragments sparingly trimmed if necessary, contused tissues cut away, counter-openings made for drainage, and the cutaneous wound sutured. A thick antiseptic dressing is applied, and over all is placed such retentive apparatus as is suitable. The main indication is to secure early union of the cutaneous wound: while this is taking place it is desirable that the fragments should remain properly reduced; but this is, in a measure, of secondary importance, for a final readjustment can usually be made in the second or even the third week. But if the wound in the skin is *small and clean*, it is advisable to limit interference to its irrigation, to the setting of the fracture as if it were simple, and to the application of an antiseptic dressing, and then after the lapse of a week, when the wound will probably have healed, to remove the dressing and make permanent reduction and retention if it has been impossible to effect this at the primary dressing.

The use of *metallic sutures* and similar devices to maintain the fragments in contact with each other is rarely advisable, since sufficient support can usually be given by an external apparatus, and the presence of the foreign body appears somewhat to retard bony union.

If *suppuration* follow from prior infection, the limb must be placed in a splint that will permit the removal of the dressings with the minimum of dis-

turbance of the fragments. Some form of interrupted plaster or suspended splint may be applied, and later indications met as they arise.

Concerning the propriety of *primary amputation* or *excision* of a joint definite rules cannot be laid down; each case must be judged according to the extent of the injury, the probable usefulness of the limb if saved, and the ability to protect against suppuration and septic infection. The protection afforded by attention to the modern principles of treatment of wounds is such that in doubtful cases the patient may safely take the benefit of the doubt and be given an opportunity to show whether or not the limb can be saved.

AFTER-TREATMENT.—After union of a broken bone has been obtained the surgeon's attention may be directed to hastening the complete return of function, the disappearance of congestion and turgescence, the reduction of the stiffness of neighboring joints, and the strengthening of the muscles. The roughness of the skin, turgescence of the limb, and weakness of the muscles can be relieved by massage and electricity, and in the case of the leg comfort will often be promoted by snug bandaging during the day. Stiffness of joints at a distance from the fracture will usually disappear under ordinary use, but special attention may be needed at the ankle to obtain dorsal flexion within a right angle. Stiffness of the fingers in the old and rheumatic is very likely to follow simple immobilization and to be very persistent. It should be guarded against by leaving the fingers uncovered during treatment of the fracture whenever that is possible, and encouraging the patients to use them; when it is necessary to immobilize them during treatment, they should be kept flexed, since stiffness is less likely to take place in that than in the extended position.

When the fracture is in the immediate neighborhood of a joint, nothing should be done in the way of passive or voluntary motion until after union is complete or at least nearly so, and then should be done with great care. The same should be the rule also when the fracture actually involves the joint, as at the elbow. The most that is permissible is the occasional slight change of the angle at which the joint is immobilized.

As regards *passive motion*, it is rarely required or even useful, and as so often employed, under ether or with production of pain, it is actually harmful. The stiffness of a joint after fracture involving it or in its immediate neighborhood is due either to mechanical changes in the joint-surfaces or the relations of the bones, which cannot be materially changed by passive motion, or to periarticular thickening the result of the traumatism, which will disappear, if its disappearance is possible, under ordinary quiet use, and will only be increased and prolonged by forcible motion, which means the infliction of further injury.

PSEUDARTHROSIS AND DELAYED UNION.¹—When abnormal mobility has not ceased after the usual lapse of time, the condition is described as **delayed union**; if this condition persists after some additional weeks, it is termed **pseudarthrosis**, or **failure of union**, or **ununited fracture**. Delayed union is not very uncommon, but failure of union is relatively rare; most of the cases occur in middle life, and most frequently in the humerus, tibia, and femur in the order mentioned. In proportion to the number of fractures of the respective bones, delayed union and failure of union occur more frequently after fracture of the shaft of the femur than after that of the tibia. Anatomically, two distinct varieties exist: in one the fragments are more or less closely bound together by solid bands of fibrous tissue, sometimes enclosing nodules of bone;

¹ The fibrous union with persistent mobility which is the rule after fracture of the patella and of some apophyses will not be here considered.

in the other similar fibrous bands enclose a central cavity containing a viscid synovia-like liquid, into which the ends of the fragments may project; and these ends may be smooth and eburnated or even covered by hyaline cartilage—a complete new joint. The clinical difference between the two varieties is important, as will appear when their treatment is considered.

The **reason** of delay or of failure of union, in the great majority of cases, lies in the arrest of the evolution of the callus before it has entered upon the stage of ossification—*i. e.* its persistence as fibrous tissue; in others the separation of the fragments is so great and the gap so broken by interposed muscle that a continuous callus, formed by granulations springing from the bones, has never existed, and the fibrous bond is composed solely of the thickened surrounding connective tissue. The ends of the fragments are variously affected in accordance with the extent of the rarefying and productive processes which follow the injury; according as one or the other predominates the ends are diminished in size, sometimes to slender conical points, or enlarged by the formation of irregular masses of bone upon them. In a very few cases the rarefying process has gone so far that a large portion, or even the whole, of the shaft has gradually disappeared. This tendency to excessive rarefaction, when present, is a serious obstacle to the success of operations undertaken to secure union, and it has seemed to some writers to be increased by the presence of metallic sutures binding the fragments together. Occasionally the fragments are in close apposition by their broad surfaces, the fibrous bond is short and complete, and the fragments are enlarged by peripheral productions of bone, and yet ossification of the short fibrous bond fails.

The resultant **disability** varies with the amount of abnormal mobility and the uses to which the limb is put: thus, failure of union in the leg or thigh may make the limb wholly useless, while in the arm or forearm it may interfere but slightly with its usefulness.

With respect to the **cause**, certain general conditions have seemed at times to delay repair, such as syphilis, pregnancy, and acute general diseases, but the common causes are local. Advanced age is not a cause. The local causes are separation of the fragments (by displacement or by loss of substance), the interposition of a foreign body or of a portion of muscle, disease of the bone, defective blood-supply, defective innervation, inflammation on the surface of the limb, and faulty treatment.

The first three act mechanically by creating a gap that cannot be filled by the granulations, and, in addition, in the third the surfaces may be so modified by the disease (syphilis, caries, cancer, etc.) that they are unfit to furnish the necessary granulations. Defective blood-supply, the result of injury to the nutrient artery of the bone or to the main artery of the limb, has often been alleged as a cause, but satisfactory proof is lacking and theoretical considerations do not furnish much support. The influence of defective innervation has been shown in some fractures of the lower limb combined with injury to the lower part of the spinal column; it appears to arise not from the same cause that produces the paralysis of motion, for such delay does not occur in paraplegia due to injury at the upper part of the spinal column, but from injury to trophic centers in the lower part of the cord. The influence of surface inflammation has been occasionally shown in the delay of repair or in the softening of a firm callus coincidently with the appearance of an erysipelas or a phlegmon of a limb.

Excluding incomplete reduction, the fault in treatment which is most likely to delay or prevent repair is insufficient immobilization. Its influence is

unquestionable, although of course it is known that union may take place in spite of it. It is thought that the relative frequency of failure of union after fracture of the humerus is largely due to this cause. The local application of cold is also thought to retard union. It has been asserted also that treatment by complete encasement of the limb in a plaster-of-Paris bandage is followed by a larger proportion of delays and failures than is the case where other methods are employed, and that the increase is due to the shutting out of air and light from the limb: a more probable explanation of the frequency, if it actually exists, is defective immobilization. Premature use of the limb may be followed by a gradual return of the abnormal mobility, as well as by distinct refracture; and a similar occurrence has been observed under the influence of intercurrent diseases weeks or even months after union appeared to be complete.

Treatment.—If a general cause exists, such as syphilis or malnutrition, measures should be taken to remove it, whether the case is one of delayed union or of failure of union. In delayed union of short duration, and with only slight mobility and displacement, much is to be hoped from time, aided by accurate immobilization by splints that will permit the patient to leave his bed.

A gratifying number of successes in fractures of the leg and thigh have been obtained by the use of orthopedic splints. In a number of cases of delayed union of the leg union has gradually become complete while the patient was using the limb under the protection of a suitable splint: it is thought that the slight irritation caused by bearing the weight upon the limb favors ossification. On the same theory percussion of the bone at the fracture has been used. If the case is of longer standing and the mobility greater, a more decided local irritation is required—one that will bring the parts more nearly to the condition of a recent fracture and start the process of repair afresh. Under anesthesia the limb is *forcibly bent* at the seat of fracture, care being taken not to injure main vessels and nerves. The bending should be nearly or quite to a right angle, and the laceration should be sufficient to permit a fairly complete reduction if there has been previous displacement. The fracture is then treated as a recent one.

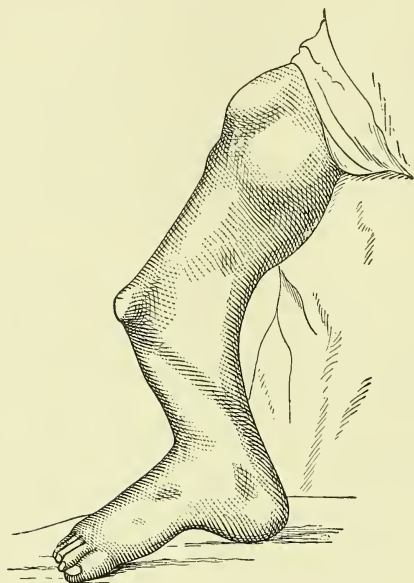
Direct irritation of the ends of the bones can be produced by subcutaneous drilling, but it seems better, and, if antiseptically done, is equally safe, to expose the bone by incision and apply the drill under the guidance of the eye and finger: it should be forced into the end of each fragment at several points. This plan is, in the writer's judgment, more efficient than the permanent introduction of metallic, bone, or ivory pins.

Excision of the fibrous tissue and of the end of each fragment is the only means that will cure old cases and those in which a joint-cavity has formed between the fragments. Under the protection of antiseptic treatment of the wound it has become a popular method, and has proved safe and efficient. The bones should be freely exposed, and their surfaces freshened and fitted to each other—preferably by a transverse section, if that does not require the removal of too much tissue—and the periosteum should be stitched together as extensively as is practicable. Buried or temporary sutures of silver wire or of strong silk are sometimes used to bind the fragments together and prevent displacement; as are also long, narrow metal plates on each side of the bone, crossing the line of fracture and secured to the fragments by long pins that are left projecting beyond the skin and are removed after two or three weeks, the plates being left to heal in.

The attempt has been successfully made in a few instances to obtain union, when there was a considerable gap between the fragments due to loss of substance,

by *filling the gap with small pieces of sterilized decalcified bone* or of fresh bone taken from animals: the intermediate fibrous tissue is removed, the ends of the

FIG. 85.



Faulty Union after Fracture (original).

fragments freshened, and the skin closed over the inserted pieces; perfect asepsis is necessary to success.

Finally, *amputation* may be required to rid the patient of a useless and troublesome limb.

FAULTY UNION.—An operation may be required to relieve a disability due to union with deformity or to exuberant callus: thus, the femur may have united with an angular displacement that causes effective shortening of the leg in such manner that the foot does not rest squarely on the ground or is outside the line of support; or the bones of the forearm may unite with a callus that prevents rotation; or an exuberant callus may compress a nerve. Fig. 85, from a photograph, is an example of union with extreme

deformity. The measures employed are subcutaneous refracture, osteotomy, and chiselling away of exuberant bone. (See Operations on Bones.)

SPECIAL FRACTURES.

FRACTURES OF THE SUPERIOR MAXILLA AND MALAR BONES.

These are caused only by direct violence, are generally comminuted, and unite with great rapidity. Displacements may often be corrected by direct pressure, and, except in the case of the alveolar border, require no retentive apparatus. When a portion of the alveolar border, with more or less of the adjoining bone, is loosened, it may need to be retained by wiring its teeth to the neighboring ones or by keeping the lower jaw pressed against it.

FRACTURE OF THE NASAL BONES.

This is produced by direct violence, and is often compound, either through the skin or through the mucosa. The fracture may extend to the superior maxilla or to the cribriform plate of the ethmoid; the latter is a dangerous complication because of the possibility of septic meningitis. Cellular emphysema of the face and eyelids, due to the forcing of air through the lacerated mucosa by efforts to clear the nostrils, may appear. Repair takes place so rapidly that it is necessary to recognize and reduce displacements promptly. Reduction is best made by pressure with a small stiff metal rod, like a director, passed into the nostril. Ordinarily there is but little tendency to recurrence of the displacement, but it may sometimes be necessary to oppose it. A plan that has yielded good results is to transfix the nose close beneath the fragments with a

stout pin, and steady them with a piece of india-rubber or adhesive plaster crossing the bridge of the nose and caught upon the ends of the pin.

Suppuration may be followed by necrosis of the fragments. Possibly it could be prevented by irrigating the nostrils with an antiseptic solution and plugging the passage with iodoform gauze. This should always be done very carefully if injury to the cribriform plate is suspected. (See Fractures of the Base of the Skull in the section on Injuries of the Head.)

FRACTURE OF THE LOWER JAW.

This may be single or double: single fractures are most common at or near the median line; those of the ramus and condyloid process are much rarer. Double fractures may occupy one or both sides, or one of the fractures may be in the median line. They are quite common. Fractures of the body of the bone are usually compound; those of the coronoid process are extremely rare, and have been found only in connection with fractures of the condyle, zygoma, and malar bone.

The **displacement** in fractures of the body is almost invariably such that the level of the teeth on one side of the fracture is lower than on the other, and with this is often associated an antero-posterior or lateral displacement according to the position of the fracture; sometimes there is overriding. In fracture of the ramus there is usually little or no displacement.

The common **cause** is violence received upon the chin or cheek.

The **diagnosis** is readily made in fractures of the body by recognition of the change in the relations of the teeth, of abnormal mobility and crepitus, and usually of looseness of the adjoining teeth and bleeding from the gums. In fracture of the ramus the only symptom may be pain on pressure or on tightly closing the jaws. The pain should be sought for by making pressure with the finger within the mouth as well as on the cheek.

The **course** is marked by swelling of the face and gums, and often by suppuration at the seat of fracture, the pus escaping into the mouth alongside the teeth, and also often opening through the skin near the lower border of the jaw. Suppuration may be maintained for a long time by necrosis, and may lead to a considerable loss of bone with consequent failure of union and great disability.

Reduction can almost always be readily effected by direct pressure, but the prevention of recurrence may be very difficult. In simple cases treatment consists in the application of a "four-tailed bandage" (Fig. 86); in the

more difficult cases recourse has been had to a great variety of interdental splints and methods of wiring the bones or the teeth together. For the construction of most of these the surgeon will require the services of a dentist.

FRACTURE OF THE HYOID BONE.

This is exceedingly rare, and in the few recorded cases has been caused by direct violence and has almost always involved one of the greater cornua.

FIG. 86.



"Four-tailed Bandage" for Fracture of the Jaw (Stimson).

The symptoms are sharp pain, swelling, marked dysphagia, and sometimes bleeding from the mouth due to perforation of the mucous membrane by the fragments. Death from œdema of the glottis may occur.

FRACTURE OF THE STERNUM. (See also DISLOCATIONS.)

This fracture is rare; it may be incomplete, multiple, transverse, longitudinal, or oblique, but the common form is transverse and situated at or near the junction of the manubrium and body of the bone. As a complete joint sometimes exists between the manubrium and body, it may be impossible to say whether a separation exactly following the line of their junction is a fracture or a dislocation. Displacement may be absent, or may be angular or transverse with or without overriding, either piece lying in front of the other. The periosteum on the posterior surface appears habitually to remain untorn. When the fracture takes place at the junction of the first and second pieces, the second rib usually remains in contact with the manubrium. Fractures of the body are most common in its upper half; those of the ensiform process, including its separation from the body, are extremely rare.

The fracture has been **caused** in several cases by straining during labor and by lifting heavy objects; external violence may cause fracture directly, as in a blow upon the breast, or indirectly by bending the trunk backward.

The **diagnosis** is made by recognition of the displacement when it is present, localized pain, and the history of the case. There is sometimes irregularity of the heart with dyspnœa.

The **treatment** consists in reduction by direct pressure, aided, if there is overriding, by extension of the trunk and by deep inspiration by the patient, and in retention by a broad band of adhesive plaster around the chest.

FRACTURE OF THE RIBS.

This fracture is of frequent occurrence; it may be partial or complete, single or multiple. Incomplete fractures are rare, whether by bending or by fracture of a piece from one border of the bone. Complete fracture may involve one or several ribs, or one or more ribs at two points each; the ribs most frequently broken are the fifth to the ninth; fracture of the floating ribs is almost unknown, and that of the upper ribs apparently very rare, although there is some reason to think that fracture of the first rib is not infrequent, but usually passes unrecognized.

Unless two or more adjoining ribs are simultaneously broken, there is little or no **displacement**; if they are thus broken, the displacement may be angular, with the apex directed inward or outward, and overriding may be produced by the sinking in of the chest-wall. If a rib has been broken at two places, the intermediate piece may move in and out as the patient breathes. Associated *injury to the lung* by the point of a fragment is common, as shown by emphysema or bloody expectoration; and extensive laceration of the lungs or heart may be produced when the violence is great. Serious hemorrhage from a wounded intercostal artery is rare.

The common **cause** of the fracture is external violence, but it may also be caused by muscular action, especially in coughing. External violence may produce the fracture directly, or indirectly by exaggerating the curve of the bone.

The **symptoms** in the less extensive cases are pain on deep inspiration or coughing and when pressure is made upon the broken rib; abnormal mobility can often be recognized by placing a finger on the rib on each side of the

fracture and noticing that movement communicated to one fragment is not transmitted to the other: during this manipulation crepitus may be perceived, or it may sometimes be heard by listening with the ear upon the chest while the patient breathes deeply. Bloody expectoration is frequent. The presence of cellular emphysema, in the absence of a wound or other sufficient cause, is pathognomonic. In the severer cases, in which several adjoining ribs are broken, the fracture is readily recognized by the deformity; associated symptoms due to laceration of the lung may be very urgent.

The **treatment** is habitually limited to immobilization of the chest by means of a broad band of adhesive plaster placed about it at the end of expiration. Angular displacement outward can be corrected by direct pressure upon the projection; it has been proposed to raise a depressed rib by cutting down upon it or by passing a sharp hook under it, but it is unlikely that such a measure would ever be necessary. For the treatment of associated injuries of the thoracic viscera, pneumothorax and hemothorax, the reader is referred to the chapter on Injuries of the Thorax.

FRACTURE OF THE COSTAL CARTILAGES.

This may be caused by direct or indirect violence or by muscular action; it appears to occur more frequently near the junction with the rib than at other points, and to involve the seventh and eighth cartilages more frequently than others. Marked symptoms, when present, are due to associated lesions, injury of the heart or lungs, or other effects of the crushing violence that has caused the fracture. The diagnosis is made on the local pain and the deformity. The treatment is the same as that of fracture of the ribs.

FRACTURES OF THE CLAVICLE.

The clavicle is broken more frequently than any other one bone, with the possible exception of the radius, and the injury is very much more common in the young than in adults, about half the cases occurring in children under five years of age. The fracture may be partial (green-stick) or complete, simple or compound, single or multiple. The partial (in the very young) and simple complete (in the adult) of the middle third of the bone are the common forms; fracture of the outer third is second in order of frequency; that of the inner third is infrequent. The division of fractures into those of the inner, middle, and outer thirds is justified by important anatomical and resultant clinical differences, the chief of which arise from the firm ligamentary attachments of the outer third to the coracoid process of the scapula.

Fracture of the **middle third** (Fig. 65.), the most common variety, may be oblique or transverse, the latter form being found mainly in children; the line of oblique fracture runs from above downward and inward, so that the point of the outer fragment underlies that of the inner one—an important element in the production of the usual displacement; the seat of fracture is usually in the outer half of this third. The loss of support occasioned by the fracture is followed by the falling of the shoulder *downward, forward, and inward*, which presses the outer fragment under the inner one, and thus raises the broken end of the latter—a movement which is sometimes aided by the contraction of the cleido-mastoid. If the line of fracture is so nearly transverse that overriding cannot occur, the displacement is transverse or angular with the apex directed upward and usually backward.

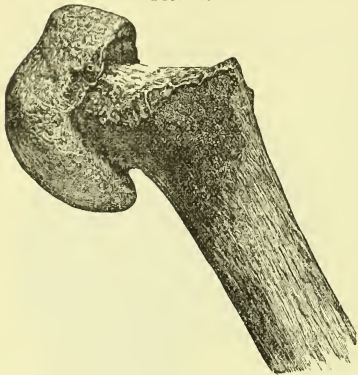
In fracture of the **outer third**, which is much less frequent than the preceding, the line of fracture is more often transverse than oblique, and the dis-

partly attached by untorn periosteum or may be entirely separated and drawn backward. The *symptoms* are loss of voluntary outward rotation, pain, crepitus, and swelling.

Of fracture of the **lesser tuberosity** only three examples have been reported, two of them in connection with the very rare dislocation of the shoulder upward, the third without history.

Separation of the epiphysis (Fig. 91) is caused by external violence, and quite frequently in the new-born by traction upon the arm or in the axilla

FIG. 91.



Separation of the Upper Epiphysis of the Humerus; Displacement Forward of the Lower Fragment (Moore).

during delivery. The displacement when not complete is transverse and angular, the apex of the angle directed forward and upward; when the displacement is complete the lower fragment lies on the inner side of the upper. The epiphysis includes the tuberosities, and is so shaped that the upper end of the shaft has the form of a low cone or wedge. The *symptoms* are commonly very characteristic in this respect, that a distinct prominence can be seen and felt on the front of the shoulder about an inch below the acromion, and that a false point of motion can be recognized by grasping the head and gently rotating the shaft; when the displacement is inward this prominence is found beneath the coracoid. *Reduction* is difficult because of the smallness of the upper

fragment, but may be effected by carrying the elbow forward and upward, as the posterior portion of the capsule attached to the upper fragment prevents it from sharing in the movement. In a few cases recourse has been had to open incision. Occasionally the growth of the limb at this point is arrested in consequence of the injury, either because the displacement persists or because the epiphyseal cartilage ossifies prematurely.

Fracture of the Surgical Neck (Fig. 92).—The surgical neck of this bone is the part between the upper expanded end and the insertion of the pectoralis major and latissimus dorsi. This is by far the most frequent fracture at the upper end; it is commonly caused by a blow upon the upper part of the arm or by a fall on the hand or elbow. The line of fracture is usually oblique and the displacement marked, the lower fragment lying oftenest on the inner side of the upper one, drawn thither by the latissimus dorsi and pectoralis major.

Symptoms.—Abnormal mobility and crepitus are recognized by grasping the head of the humerus with the thumb and fingers of one hand and gently rotating the elbow with the other.

Treatment.—Reduction is made by traction and coaptation and slowly bringing the lower fragment into line with the upper one, and, if the deformity obstinately returns, may be maintained by permanent traction with weight and pulley combined with the support of a plaster-of-Paris gutter on the back and sides of the shoulder and arm. If the line of fracture is such that the tendency to displacement is slight, or if confinement to bed is very undesirable, splints or encasement in plaster of Paris may be used. In such a case the forearm should be flexed, and supported only at the wrist by a sling, in

order that the weight of the limb may make traction while the patient is erect, or occasionally an additional weight of not more than five pounds may be hung from the elbow. A dressing consisting of a folded towel placed against the side of the chest and extending into the axilla and a little above its borders, a shoulder cap, and a sling at the wrist, gives most excellent results. The arm should be bound to the side by circular turns of a bandage, and the shoulder cap should be held in place by a spica. A splint may be used on the outer side, resting against the acromion and the elbow, the lower fragment being secured to the splint by a bandage: it opposes the displacement of the latter inward by its counter-pressure against the acromion, but does little or nothing to prevent shortening. The scapular muscles attached to the upper fragment tend to tilt its lower end forward and outward, and when this tendency is manifested it must be met by keeping the lower fragment in a corresponding position, either by traction in bed with the arm abducted or by a triangular splint or cushion placed between the arm and the side and maintaining the arm in the desired position. If, as is usual, union is quite firm after the expiration of a month, the splint may be removed and the forearm supported in a sling for a week or two longer.

When the fracture is *complicated by simultaneous dislocation* of the head, the latter may sometimes be reduced by direct manipulation under an anæsthetic, or, as recently done by McBurney, cutting down through the deltoid to the lower part of the upper fragment, drilling a hole in it, and inserting in this hole a strong right-angled hook, by means of which forcible traction and rotation can be made upon the fragment. If these fail, the surgeon has his choice between securing union of the fracture and making a subsequent attempt to reduce the dislocation and the establishment of a false joint.

Fracture of the shaft may be caused by direct or indirect violence, or by muscular action; all the varieties of fracture and displacement seen in the shafts of other long bones have been seen here. Among observed *complications* are rupture, thrombosis, and aneurysm of the brachial artery and injury of a main nerve, especially the musculo-spiral, either at the time of the accident or subsequently by inclusion in the callus. The *diagnosis* is readily made by attention to the common signs of fracture, all of which are usually present. Union takes place in from four to six weeks, but it is to be remembered that *failure of union* is more frequent after fracture of the shaft of the humerus than after that of any other long bone. The *treatment* is by an internal angular splint, a shoulder cap, and a sling at the wrist; by moulded splints; or by encasement in plaster of Paris, which should include the forearm (flexed at a right angle) and the shoulder. Unless measures are taken to prevent it, this latter dressing will show after a few days a distinct gap above the shoulder, due to the shortening of the arm—a gap that will admit one or two fingers: this may sometimes be prevented by adding a spica about the chest, but more surely and conveniently by a weight attached to the elbow. If the skin is so bruised that a permanent dressing cannot be applied, the limb must be supported on cushions in a suitable position or bound to the side of the chest.

Fractures of the Lower End of the Humerus.—In this group are included fracture close above the condyles; above and between the condyles; of either condyle; of either epicondyle; and separation of the epiphysis.

FIG. 92.



Fracture of the Surgical Neck of the Humerus (Stimson).

touch, especially along the vertebral border of the bone; by independent mobility, recognized by grasping and moving the lower angle; and by crepitus. The *treatment* consists in immobilization of the shoulder and arm; if suppuration ensues in consequence of bruising of the soft parts, early opening of the abscess is required, with especial attention to the drainage of the portion which lies on the costal surface of the bone.

Fracture of the **inferior angle** is caused by direct violence or by muscular action; the small lower fragment is displaced forward and upward by the attached muscles, and even if it can be restored to its place it cannot be maintained there.

Fracture of the **upper angle** is very rare, is caused by direct violence, is followed by but little displacement, and is to be treated by immobilization of the arm.

The entire **spine**, including the acromion, may be separated from the body of the bone, or a portion may be broken off, leaving the acromion attached to the body. The cause is direct violence; the displacement is slight; the treatment is immobilization.

Fracture of the **acromion process** may be caused by external violence acting either directly or through the humerus; or by muscular action (contraction of the deltoid). The line of fracture is in most cases in front of the articulation with the clavicle, less frequently at the root of the process. The *symptoms* are localized tenderness, abnormal mobility, and crepitus. *Non-union of the epiphysis* at the external extremity of the spine, which is not very uncommon, may, if combined with a contusion, be mistaken for a fracture. Bony union is apparently the exception, but the failure to secure it creates no disability. The *treatment* consists in immobilization of the arm at the side of the body, with the elbow a little forward, and with the humerus pressed well upward against the acromion (the Velpéau position).

Fracture of the **coracoid process** may be caused by external violence or by muscular action, and has been observed both alone and in combination with other injuries. The *symptoms* are abnormal mobility, with or without crepitus, obtained, where present, by pressure with the finger against the tip of the process. Displacement downward by the action of the attached muscles is the rule, as is also fibrous union. The *treatment* consists in immobilization of the arm upon the side of the chest with the elbow directed a little backward.

Fracture of the *surgical neck* includes all cases in which the detached fragment comprises the attachment of the long head of the triceps. The upper portion of the line of fracture may end in the suprascapular notch, or in front of the coracoid, or in the glenoid fossa. The *symptoms* are flattening of the shoulder, due to the sinking of the humerus in consequence of the loss of support by the triceps (this is less when the fracture passes through the suprascapular notch, because the fragment is then supported by the coraco-clavicular ligament); its prompt disappearance when the arm is pressed upward, and its immediate return when the pressure is removed; the presence of a movable hard lump deep in the axilla, felt by following with the finger the axillary border of the scapula upward; and crepitus, obtained by pressing it upward and backward. Bony union with some displacement appears to be the rule. The indication for *treatment* is to prevent the sinking of the humerus. This can be effected by bandages or a strip of adhesive plaster passing under the flexed elbow and over the top of the shoulder.

Fracture of the **rim of the glenoid fossa** is a complication of dislocation of the shoulder. Some authors speak of stellate fractures of the fossa, apparently the result of crushing violence acting through the head of the humerus.

FRACTURES OF THE HUMERUS.

These, which constitute about 8 per cent. of all fractures, may be conveniently grouped clinically as fractures of the upper end, of the shaft, and of the lower end.

Fractures of the **upper end** include those of the head; of the anatomical neck, with or without part of the tuberosities; of the tuberosities; separation of the epiphysis; and fracture of the surgical neck.

Fracture of the **head** is very rare, if from the group are excluded those indentations which are sometimes associated with dislocation (*q. v.*). It cannot be recognized clinically.

Fracture of the **anatomical neck** is rare: the majority of cases probably occur in connection with anterior dislocation, the head being split off by the inner lip of the glenoid fossa acting as a wedge along the line of the neck. In other cases it appears to have been caused by external violence acting upon the elbow to press the humerus against the scapula, or by a fall upon the shoulder. When associated with dislocation the *diagnosis* can be made by recognizing the independent mobility of the head, but when not so associated it cannot be grasped by the fingers so as to permit the recognition of this fact, and the diagnosis cannot be made with certainty.

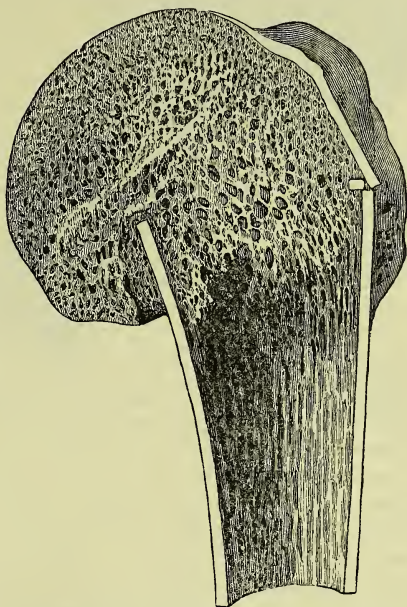
Symptoms that may be present are crepitus on rotation of the arm, with preservation of the continuity of the greater tuberosity with the shaft, and pain on pressing the elbow upward, but in a case reported by Stimson there was entire absence of objective symptoms. Hutchinson's supposition that the tonicity of the scapulo-humeral muscles, by drawing the shaft upward, tended to force the head out of the socket has not been confirmed. The *treatment* is immobilization of the arm by binding it to the chest for about four weeks; a thin compress or a layer of absorbent cotton placed between the arm and the chest to absorb the perspiration will add to the patient's comfort.

Fracture **through the tuberosities** (Fig. 90), the line of fracture running partly along the anatomical neck, and usually through the greater tuberosity, is apparently less rare than pure fracture along the anatomical neck: the fragments are commonly impacted with comminution, and in some cases the upper one has been turned completely over.

The *treatment* is immobilization of the limb, aided possibly by permanent traction downward.

Fracture of the **greater tuberosity**, complete or partial, is rarely seen except in connection with anterior dislocation; it may be caused by direct violence or by the forcible contraction of the attached muscles. The line of fracture runs along the anatomical neck adjoining the tuberosity, down the bicipital groove, and through or below the tuberosity; the fragment may remain

FIG. 90.



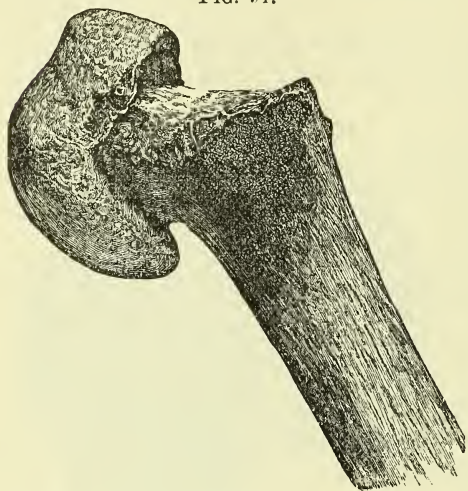
Impacted Fracture of the Humerus through the Tuberosities (R. W. Smith).

partly attached by untorn periosteum or may be entirely separated and drawn backward. The *symptoms* are loss of voluntary outward rotation, pain, crepitus, and swelling.

Of fracture of the **lesser tuberosity** only three examples have been reported, two of them in connection with the very rare dislocation of the shoulder upward, the third without history.

Separation of the epiphysis (Fig. 91) is caused by external violence, and quite frequently in the new-born by traction upon the arm or in the axilla during delivery. The displacement

FIG. 91.



Separation of the Upper Epiphysis of the Humerus; Displacement Forward of the Lower Fragment (Moore).

when not complete is transverse and angular, the apex of the angle directed forward and upward; when the displacement is complete the lower fragment lies on the inner side of the upper. The epiphysis includes the tuberosities, and is so shaped that the upper end of the shaft has the form of a low cone or wedge. The *symptoms* are commonly very characteristic in this respect, that a distinct prominence can be seen and felt on the front of the shoulder about an inch below the acromion, and that a false point of motion can be recognized by grasping the head and gently rotating the shaft; when the displacement is inward this prominence is found beneath the coracoid. *Reduction* is difficult because of the smallness of the upper

fragment, but may be effected by carrying the elbow forward and upward, as the posterior portion of the capsule attached to the upper fragment prevents it from sharing in the movement. In a few cases recourse has been had to open incision. Occasionally the growth of the limb at this point is arrested in consequence of the injury, either because the displacement persists or because the epiphyseal cartilage ossifies prematurely.

Fracture of the Surgical Neck (Fig. 92).—The surgical neck of this bone is the part between the upper expanded end and the insertion of the pectoralis major and latissimus dorsi. This is by far the most frequent fracture at the upper end; it is commonly caused by a blow upon the upper part of the arm or by a fall on the hand or elbow. The line of fracture is usually oblique and the displacement marked, the lower fragment lying oftenest on the inner side of the upper one, drawn thither by the latissimus dorsi and pectoralis major.

Symptoms.—Abnormal mobility and crepitus are recognized by grasping the head of the humerus with the thumb and fingers of one hand and gently rotating the elbow with the other.

Treatment.—Reduction is made by traction and coaptation and slowly bringing the lower fragment into line with the upper one, and, if the deformity obstinately returns, may be maintained by permanent traction with weight and pulley combined with the support of a plaster-of-Paris gutter on the back and sides of the shoulder and arm. If the line of fracture is such that the tendency to displacement is slight, or if confinement to bed is very undesirable, splints or encasement in plaster of Paris may be used. In such a case the forearm should be flexed, and supported only at the wrist by a sling, in

order that the weight of the limb may make traction while the patient is erect, or occasionally an additional weight of not more than five pounds may be hung from the elbow. A dressing consisting of a folded towel placed against the side of the chest and extending into the axilla and a little above its borders, a shoulder cap, and a sling at the wrist, gives most excellent results. The arm should be bound to the side by circular turns of a bandage, and the shoulder cap should be held in place by a spica. A splint may be used on the outer side, resting against the acromion and the elbow, the lower fragment being secured to the splint by a bandage: it opposes the displacement of the latter inward by its counter-pressure against the acromion, but does little or nothing to prevent shortening. The scapular muscles attached to the upper fragment tend to tilt its lower end forward and outward, and when this tendency is manifested it must be met by keeping the lower fragment in a corresponding position, either by traction in bed with the arm abducted or by a triangular splint or cushion placed between the arm and the side and maintaining the arm in the desired position. If, as is usual, union is quite firm after the expiration of a month, the splint may be removed and the forearm supported in a sling for a week or two longer.



FIG. 92.
Fracture of the
Surgical Neck
of the Humerus
(Stimson).

When the fracture is *complicated by simultaneous dislocation* of the head, the latter may sometimes be reduced by direct manipulation under an anesthetic, or, as recently done by McBurney, cutting down through the deltoid to the lower part of the upper fragment, drilling a hole in it, and inserting in this hole a strong right-angled hook, by means of which forcible traction and rotation can be made upon the fragment. If these fail, the surgeon has his choice between securing union of the fracture and making a subsequent attempt to reduce the dislocation and the establishment of a false joint.

Fracture of the shaft may be caused by direct or indirect violence, or by muscular action; all the varieties of fracture and displacement seen in the shafts of other long bones have been seen here. Among observed *complications* are rupture, thrombosis, and aneurysm of the brachial artery and injury of a main nerve, especially the musculo-spiral, either at the time of the accident or subsequently by inclusion in the callus. The *diagnosis* is readily made by attention to the common signs of fracture, all of which are usually present. Union takes place in from four to six weeks, but it is to be remembered that *failure of union* is more frequent after fracture of the shaft of the humerus than after that of any other long bone. The *treatment* is by an internal angular splint, a shoulder cap, and a sling at the wrist; by moulded splints; or by encasement in plaster of Paris, which should include the forearm (flexed at a right angle) and the shoulder. Unless measures are taken to prevent it, this latter dressing will show after a few days a distinct gap above the shoulder, due to the shortening of the arm—a gap that will admit one or two fingers: this may sometimes be prevented by adding a spica about the chest, but more surely and conveniently by a weight attached to the elbow. If the skin is so bruised that a permanent dressing cannot be applied, the limb must be supported on cushions in a suitable position or bound to the side of the chest.

Fractures of the Lower End of the Humerus.—In this group are included fracture close above the condyles; above and between the condyles; of either condyle; of either epicondyle; and separation of the epiphysis.

In fracture above the condyles, or supracondyloid fracture, the line of fracture passes through the expanded lower end of the humerus, and may open into the joint through the olecranon and coronoid fossæ; the line may be transverse or oblique, either laterally or antero-posteriorly, and in a few cases has been almost vertical and transverse—*i. e.* parallel to the anterior surface, crossing the bone close behind the trochlea and capitellum.

Symptoms.—The usual displacement is of the lower fragment backward, and the injury is often compound because of perforation of the skin by the sharp end of either fragment, especially the upper. The brachial artery or median nerve may be dangerously stretched across the end of the upper fragment. When the usual displacement is present the general appearance of the region resembles that of dislocation backward of the elbow. The *diagnosis* is then made by attention to the relations of the olecranon and head of the radius to the epicondyles.

Treatment.—Reduction, which is sometimes very difficult, is made by traction and coaptation with the elbow flexed at a right angle or fully extended, and is maintained by posterior and anterior rectangular splints or by a moulded posterior splint or trough that extends well around to the front on both sides; occasionally vertical suspension for a fortnight with the elbow fully extended is the best, especially if the fracture is compound; and this attitude has the advantage of being followed by less primary stiffness of the joint than is usual after treatment in flexion. In compound fractures excision of the end of one or both fragments may be needed to secure permanent reduction.

Intercondyloid fracture, sometimes called T- or Y-fracture, differs from the preceding by the addition of a line of fracture running from the transverse one downward through or between the condyles; it is usually caused by direct violence, a blow or fall upon the elbow, and is often comminuted or compound.

Symptoms.—It may closely resemble a supracondylar fracture, the condyles preserving their relations with each other, or the latter may be widely separated, with the lower end of the upper fragment and the olecranon interposed between them.

Treatment.—Complete reduction, in attempting which the aid of anesthesia should always be had, is very difficult, as is also its maintenance. It is to be expected that the movements of the joint after recovery will be seriously restricted, and it is well, therefore, to keep the limb during treatment, or at least during the later weeks of treatment, in the attitude which will be the most useful if ankylosis ensues. A broad, heavy, posterior moulded splint reaching from the shoulder to the wrist, with the elbow flexed at a right angle, extending well around to the front of the limb, and allowed to harden while anesthesia is maintained, is probably the best; it may be aided by permanent traction at the elbow in the direction of the long axis of the arm. Full extension during the first two weeks with the arm in a padded anterior splint is thought by many surgeons to prevent the displacement upward and backward which often occurs. Whatever method of treatment is first employed, after ten days or two weeks it is desirable to flex the elbow and to change the angle of flexion from time to time, in the hope of increasing the range of motion. In *compound fractures* advantage may sometimes be taken of the wound to pin the fragments together with steel drills passed through them; in other cases excision of the lower end of the humerus is advisable with the object of obtaining a movable, though weaker, joint.

Fracture of the internal epicondyle may be caused by direct violence or by forced abduction of the extended forearm; in the latter case dislocation of the elbow usually follows in consequence of the continuation of the violence,

and the fracture becomes a complication or an incident of the more important injury.

The *diagnosis* in the pure cases is made by recognition of the mobility of the small fragment, possibly with crepitus: in those in which it complicates a dislocation backward the diagnosis is made in the same manner; but in dislocations outward the fragment is liable to be drawn down below the trochlea, where it cannot be felt, and the diagnosis must then be made upon its absence.

The *treatment* is by immobilization of the joint for about a fortnight in flexion at or within a right angle, to diminish the effect of the attached flexor muscles upon the fragment.

Fracture of the external epicondyle is very rare; the diagnosis must be made upon the recognition of a small movable fragment at the seat of the epicondyle.

Fracture of the Internal Condyle (Fig. 93).—The line of fracture extends from a point on the inner side of the humerus above the epicondyle downward and outward into the joint at the center of the trochlea or between the center and the capitellum. The usual *displacement* is of the fragment upward and backward, and, even if it is but slight, the persistence produces marked deformity by changing the relations of the long axis of the arm and making the external condyle unduly prominent. The tonicity of the triceps appears to favor recurrence of this displacement, as does also pressure upon the upper part of the ulna when the elbow is flexed. This undesirable pressure may be readily exerted by a supporting sling, with or without a splint, and consequently the arm should be supported only at the wrist.

Treatment.—If care be taken to avoid such pressure and to make complete reduction in the first instance, satisfactory results can usually be obtained by treatment in a posterior rectangular or moulded splint or trough, or even in a plaster-of-Paris dressing, but it is advisable to examine the joint at the end of a week or ten days and correct the displacement if it has recurred. Treatment with the joint in full extension enables us more surely to avoid this displacement of the condyle upward, and has given many excellent results, but the attitude is not so convenient to the patient as that of flexion, and in some cases there is a tendency to displacement forward or tilting of the fragment in the extended position. If it is employed at all, it is perhaps sufficient to employ it during the first fortnight, and then to substitute flexion. The ultimate result in the young may be greatly impaired by excessive formation of callus.

A *complication* occasionally seen is coincident dislocation of the radius backward; that is, both bones of the forearm and the internal condyle are displaced backward, the ulna preserving its relations with the latter and with the radius. Recurrence after reduction is best avoided by keeping the elbow flexed at less than a right angle.

Fracture of the External Condyle.—In this the line of fracture runs from a point on the supinator ridge downward and inward through the capitellum or the outer part of the trochlea. Ordinarily the displacement is slight, but it may be considerable, with coincident displacement of the ulna from the internal condyle outward or backward, the head of the radius maintaining its relations with the capitellum and ulna. The *treatment* is immobilization in a posterior rectangular splint or immovable dressing.

Fig. 93.



Fracture of the Internal Condyle of the Humerus, displacement upward and inward (Gurlt).

Separation of the epiphysis is not a frequent accident, and there have been but few opportunities for direct examination of specimens. The lower fragment usually comprises the entire epiphysis, which is composed of several distinct pieces, but it is possible that either or both epicondyles may remain attached to the upper fragment. The *symptoms* and *treatment* are in the main the same as those of supracondylar fracture, of which the injury may be considered a low form. In order to prevent angular displacement Mr. Hutchinson has recommended treatment with the elbow fully flexed.

After-treatment of Fracture at or near the Elbow.—When union after fracture about the elbow is complete and the splints are laid aside, the elbow is usually very stiff, and much anxiety may be felt concerning its future usefulness; but in the great majority of cases the range of motion will rapidly increase under natural use of the limb, and the surgeon can do but little to hasten it. Daily forcing of the joint is more likely to do harm than good, and the best results are obtained by simply encouraging the patient to make as much use as possible of the limb, and perhaps aiding him by elastic traction from the wrist to the shoulder to increase flexion, and making him carry a weight in the hand to increase extension.

FRACTURES OF THE RADIUS AND ULNA.

Fracture of the olecranon may be *caused* by the contraction of the triceps or by external violence received upon the olecranon or upon the ulna near it, the commonest cause being a fall or blow upon the elbow. The line of fracture may be at right angles to the long axis of the bone in both planes, or oblique in either plane, or irregular. The *displacement* may be slight, the periosteum being in great part untorn, or the fragment may be drawn one or two inches upward by the triceps. The *symptoms* are localized pain, independent mobility, and crepitus when there is but little displacement, and the absence of the olecranon from its proper place and its presence at a higher point when there is much displacement.

Treatment.—If the displacement is slight and the olecranon accompanies the ulna in the flexion of the elbow, no other treatment is required than immobilization of the limb in a sling or an immovable dressing; but if the olecranon is completely detached and drawn upward, the elbow must be immobilized in full extension by a long anterior splint, and the fragment be held down by strips of adhesive plaster or india-rubber traction or the turns of a roller bandage. Of these various methods, one of the simplest and most effective is a U-shaped strip of adhesive plaster the curve of which lies on the back of the arm close above the fragment and the sides are carried down upon the forearm. In a few cases the fragments have been exposed by incision and wired together, but except in old cases with failure of union and much disability this is hardly justifiable. Union may be bony or fibrous, and even when union fails active extension is not always entirely lost.

Fracture of the coronoid process is almost unknown except as a complication of dislocation of the elbow backward; the tendency to displacement is not great, for the only muscle that is attached to the process, the brachialis anticus, is also broadly attached to the front of the ulna below it, and this broad attachment must be broken before the muscle can draw the fragment upward. The fragment can sometimes be felt as a small movable body in the flexure of the elbow. The *treatment* is by immobilization of the joint flexed at a right angle.

Fracture of the head of the radius has been observed mainly in con-

nection with fracture of the coronoid process of the ulna as a complication of dislocation of the elbow; it is partial, the fragment being the inner or anterior portion of the head. If the fragment is so far displaced that a positive diagnosis can be made, it should be removed.

Of **fracture of the neck of the radius** a few cases have been recorded: it may be followed by suppuration of the joint or by bony union. The clinical histories are not sufficient to permit a systematic description: possibly the *diagnosis* could be made by localized pain and by recognition of the failure of the head to share in rotatory movements of the shaft of the radius.

Fracture of the Shaft of One or of Both Bones of the Forearm.—Fracture of both bones is frequent in the lower and middle thirds, rare in the upper third. Usually the radius is broken at a somewhat higher point than the ulna. They may be broken by direct or indirect violence, and rarely by muscular action. Partial, “green-stick,” fractures are not uncommon in the young. Fracture of the ulna alone is commonly due to direct violence, a blow upon the raised arm, but it may be caused by a fall upon the hand, and is then occasionally complicated by dislocation of the head of the radius forward and upward. Fracture of the radius alone is less frequent than that of the ulna, and may be caused by direct or indirect violence.

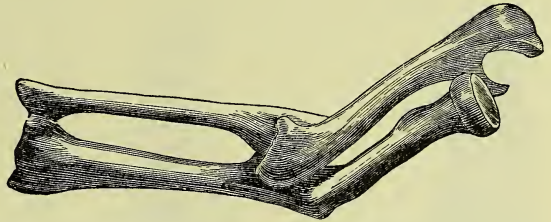
The *displacement* may be angular or lateral or with overriding, and is of especial importance because of its effect, if unreduced, upon the function of rotation of the forearm. Rotatory displacement of the upper fragment of the radius occurs especially when the fracture is above the insertion of the pronator radii teres; the unopposed action of the biceps supinates it, and the result, if uncorrected, is to limit supination of the limb: a study made by Callender of the specimens in the London museums showed such displacement varying between six and forty degrees.

The action of the biceps may also produce angular displacement by flexing the upper fragment. Rotation of the forearm may be lost in consequence of excessive formation of callus, of the union of the callus on the two bones (Fig. 94), or of ossification of the interosseous ligament.

The *diagnosis* of fracture of both bones is easy, that of either bone alone may be more difficult: independent mobility in the radius may be recognized by observing that the head of the radius does not share in slight rotatory movements communicated to the lower end; in isolated fracture of the ulna there is localized pain, often a corresponding irregularity in outline that is easily recognizable, and sometimes independent mobility can be obtained. The position of the head of the radius should always be verified in case of fracture of the ulna alone, for its dislocation forward and upward is a not infrequent complication.

Treatment.—Reduction is made by traction, with or without pressure upon the projecting angle when one exists, pressure being necessary in “green-stick” fractures; and by deep pressure with the fingers in front and behind to press the bones apart if they have been approximated. Anterior and posterior padded splints, long enough to reach from below the palm to the elbow and wide enough to prevent circular constriction of the limb by the bandage that

FIG. 94.



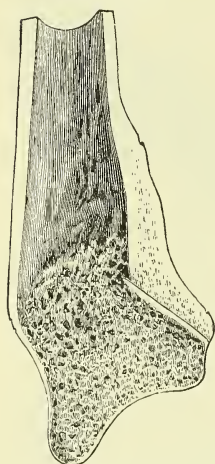
Fracture of the Forearm, angular displacement, and union between the bones (Stimson).

secures them in place, are usually sufficient to maintain reduction. The forearm should be midway between pronation and supination. Frequent inspection is necessary at first to detect dangerous constriction. Gangrene has occurred from pressure of the upper end of the palmar splint against the brachial artery at the bend of the elbow. This splint may, therefore, with advantage be made from one to three inches shorter than the posterior one. For the same reason it is well to apply the splints while the forearm is flexed upon the arm. The supporting sling should not rest against the ulna. If there is reason to guard against supination of the upper fragment by the biceps, the wrist must be correspondingly supinated; this position is somewhat irksome, and has the disadvantage of bringing the bones nearer together at the center than they are when the limb is in the midway position. After two or three weeks a moulded plaster-of-Paris dressing may be substituted for the splints. In simple fracture of the radius or ulna alone without displacement moulded plaster of Paris may be safely used even earlier. If dislocation of the head of the radius forward and upward has occurred in connection with fracture of the ulna alone, the limb should be dressed after reduction, with the elbow flexed at less than a right angle.

Fracture of the lower end of the radius (Colles's Fracture) is one of the most common of all fractures; it is seen at all ages, but with the greatest frequency in the old. It is generally produced by a fall upon the palm of the hand. The *line of fracture* is usually situated at from one-

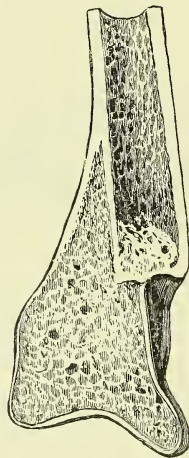
third to three-fourths of an inch above the articular edge, and is transverse, but may be oblique in either direction, and sometimes the lower fragment is comminuted. In the young it appears usually to follow the epiphyseal line. The common *displacement* is of the lower fragment backward (Figs. 95 and 96), with ascent of the styloid process by crushing, and of the posterior articular border by tilting or angular displacement, so that the articular surface looks downward and backward instead of downward and forward. The periosteum on the back of the bone remains unturned, but is stripped up from the upper fragment so as to form a "periosteal bridge;" the consequent formation of bone in the interval gives to specimens of old unreduced fractures the appearance of deep penetration

FIG. 95.



Recently-unioned Fracture of the Lower End of the Radius (R. W. Smith).

FIG. 96.



Fracture of the Lower End of the Radius, displacement of broken fragment backward (Stimson).

of the lower by the upper fragment. Exceptionally the styloid process of the ulna may also be broken off, or even the shaft of the ulna broken close above its lower end.

The *symptoms* are a characteristic deformity, consisting in a prominence on the back of the forearm close above the wrist corresponding to the lower fragment, producing what is often called the "silver-fork" deformity (Fig. 97), and a fulness on the palmar surface at a somewhat higher level, corresponding to the end of the upper fragment; the ascent of the styloid process of the radius to or above the level of that of the ulna; pain on pressure along the line of

the fracture posteriorly; and swelling of the front of the wrist, with deepening

FIG. 97.



"Silver-fork" Deformity of Colles's Fracture, photographed half an hour after the accident (original).

of the transverse lines between it and the hand. Crepitus and abnormal mobility are often absent.

Treatment.—Reduction, which at times is very difficult and even impossible, should be first attempted by traction upon the hand and direct pressure upon the fragments; if that fails, the wrist should be placed in forced extension and the fragment pressed downward by the surgeon's thumbs while his fingers grasp the forearm above the fracture. If this also fails, an anesthetic should be given, and the fragment mobilized by pressing it backward, and then forced forward into place. It is of great importance to the appearance of the limb that the posterior displacement should be fully corrected: that which is due to the crushing of the spongy tissue and shortening of the outer border of the bone cannot be corrected. If reduction is well made, there is but little tendency to recurrence. The limb is then placed between short anterior and posterior splints, the former padded lightly at the point corresponding to the end of the upper fragment, and the latter more thickly where it rests against the lower fragment, and the splints fastened by a circular strip of adhesive plaster near each end and at the middle, or held in place by a roller bandage. The posterior splint should end at the wrist; the anterior one may end at the same level, or may be carried to the palm with a pad at its lower end, over which the fingers may partly close. Similar anterior and posterior moulded splints of plaster of Paris are very convenient and equally secure. Many surgeons prefer after reduction to place the hand in flexion on a Levis's metallic splint. In cases where there is little tendency to displacement of the lower fragment a Bond's splint with the wedge-shaped compresses, as above, will give excellent results. The dressing of Barton is that preferred by some surgeons, and varies a little from the one just described. Two wedge-shaped compresses and two light, well-padded splints, long enough to reach from the elbow to the tips of the fingers, are employed. The compresses are placed over the region of the fracture, one on the dorsum of the wrist with its base upward and resting on the upper end of the lower fragment, the other on the front of the wrist, its base downward and corresponding to the lower end of the upper fragment. They are held in place by a few turns of a roller; the anterior splint (the shorter of the two) is next put in position, and the roller is carried over it while extension is kept up by an assistant, and then the posterior splint is applied. The arm is kept midway between pronation and supination; the thumb is left free. Passive motion of the fingers

should be constantly made. In the young, growth of the bone may be arrested by the traumatism, with a resultant deformity resembling that of a fracture with much crushing of the spongy tissue.

Fracture of the anterior or posterior lip of the lower end of the radius is an occasional accompaniment of dislocation of the carpus forward or backward respectively; the latter is known as *Barton's fracture*.

Fracture of a metacarpal bone may be produced by direct or indirect violence; the diagnosis is made by localized pain increased by pressing the corresponding finger upward, and perhaps by abnormal mobility and crepitus. The tendency to displacement is slight, and no special treatment is required other than a palmar splint padded to preserve the concavity of the metacarpus.

Fractures of the phalanges are usually the result of direct violence, and are often compound. In fracture of the proximal phalanx there is a marked tendency to angular displacement with the apex directed forward, which if left unreduced is the source of considerable disability. A convenient and efficient *treatment* is to close the fingers over a cylindrical roller bandage of suitable size, and bind them there with longitudinal strips of adhesive plaster or another roller bandage outside; or a padded palmar splint may be employed.

FRACTURES OF THE PELVIS.

These fractures include complete fractures at one or more points of either or both innominate bones, and fractures of any of the three bones constituting the innominate.

Fracture of the ring of the pelvis is caused by great external violence, such as the passage of the wheel of a wagon across the bone, the fall of a heavy object, the caving in of an embankment, the kick of a horse, or a fall from a height. It may be single, double, or multiple. The most frequent *seat* is in the pubic bone, the line of fracture passing through the upper ramus just internally to the ilio-pectineal eminence, and through the lower ramus near its junction with the ischium. With the anterior fracture may be associated a posterior one (double vertical fracture of the pelvis), either in the ilium behind the acetabulum or in the sacrum, or partly in either bone and partly along the sacro-iliac synchondrosis, or another anterior one through the opposite pubic bone. *Separation of either symphysis* is the practical equivalent of a fracture, but *separation of the pubic symphysis* alone may be occasioned by much slighter violence than that which is required for a fracture; *separation of both symphyses* is caused only by great violence, and is usually described as dislocation of the os innominatum. The pubes is sometimes broken in two places or comminuted. An exceptional form of fracture of the lateral portion of the ring is that in which the violence is exerted through the femur and produces a radiating fracture of the acetabulum.

Associated injuries are common and severe: the most frequent in the male is rupture of the membranous portion of the urethra (see Injuries of the Urethra), the laceration extending in severe cases through the perineum and around the rectum and anus; rupture of the bladder is next in frequency, and then injuries of other abdominal viscera.

The *displacement* is sometimes very marked, so that it is easily recognized by the finger and eye; in other cases the diagnosis must be made by localized pain caused by direct pressure or by pressure inward or backward upon the wing of the ilium. The patient is unable to raise the leg from the bed. Rupture of the urethra is indicated by bleeding from the meatus.

The *treatment* of the fracture consists in immobilization of the pelvis by a

girdle, aided in double vertical fracture by traction upon the limb, as after fracture of the thigh. If the fracture is compound, ample drainage must be provided, and if the urethra is injured, perineal section must be made.

Transverse fracture of the sacrum is very rare, and has always been caused by direct violence. It is frequently associated with paralysis of the bladder, rectum, and lower limbs. The displacement is angular, with the apex directed backward, and can be corrected by pressing the coccyx forward.

Fracture of the coccyx, which is very rare, resembles in symptoms and treatment dislocation of the same bone.

Fractures of the wing and processes of the ilium are comparatively frequent. The crest of the ilium may be broken off by direct violence, the size of the fragment varying greatly in the different cases. The anterior superior spinous process has been broken off by direct violence and by muscular action; the posterior inferior and the anterior inferior, by direct violence. The diagnosis is made by recognition of a movable fragment with crepitus. No special treatment other than rest in bed is required.

The **ischium** has been broken in a few cases by direct violence, as a fall upon the buttocks; the fragment in some cases has included almost the entire bone, in others only the tuberosity.

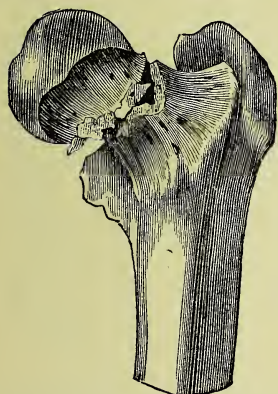
Fracture of the pubes not extending across both rami is rare: we have seen one case in which the upper half of the body and the adjoining part of the horizontal ramus were broken off; the fracture was compound, and the fragment was removed.

Fracture of the rim of the acetabulum is a complication of dislocation of the hip.

FRACTURES OF THE FEMUR.

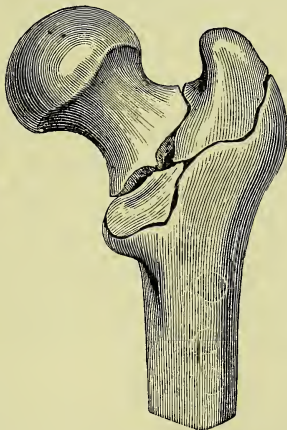
Fracture of the Neck of the Femur.—This is far more common in elderly people, especially in women, than in the young or middle-aged, and is

FIG. 98.



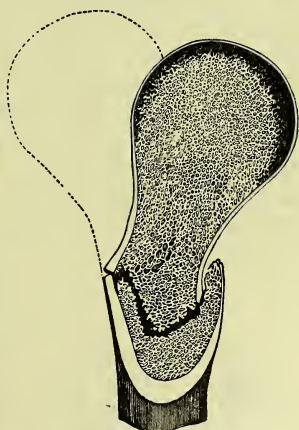
Fracture at the Small Part of the Neck of the Femur (Stimson).

FIG. 99.



Fracture at the Base of the Neck of the Femur, with splitting of the great trochanter (Stimson).

FIG. 100.



Impacted Fracture at the Base of the Cervix Femoris, with bending of the head backward (Bigelow).

generally caused in them by comparatively slight violence, as a fall while walking, a misstep, or even the effort to avoid a fall. The old classification as **intra-** and **extra-capsular** fractures, which was always unsatisfactory and took no account of the large group of "mixed" fractures in which the

line lay partly within and partly without the capsule, has now in great part given place to a division into *fractures at the base of the neck* and *fractures at the small part of the neck*.

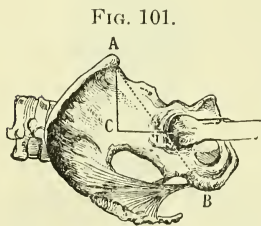
In **fractures at the small part of the neck** (Fig. 98) the line of fracture crosses the neck transversely or obliquely, and is rarely impacted: a portion of the periosteum, usually on the anterior and inferior surface, commonly remains un torn and aids in supplying blood to the head. Bony union is possible, but unlikely. Separation of the epiphysis, which is constituted by the head alone, occasionally happens, and belongs in this group.

In **fracture at the base of the neck** (Fig. 99), the more common variety, the line of fracture follows more or less closely the junction of the shaft and neck; the fragments are often impacted (Pl. XII, Fig. 2), and the great trochanter split; the crushing or impaction appears commonly to be greater at the back than at the front, so that the neck is inclined backward from its normal position with reference to the shaft, or, in other words, the shaft is in outward rotation upon the neck (Fig. 100). Bony union is the rule, and often with excessive production of bone about the fracture and the trochanter.

The *symptoms* of both varieties are inability, often complete, to use or move the limb; but occasionally the patient has been able to raise the limb from the bed or even to walk a short distance. As a rule, however, the limb lies straight and helpless on the bed, the foot is everted, the upper part of the thigh is fuller and rounder than usual. Complaint is made of pain at the hip, and often in the anterior and inner part of the middle of the thigh. Pain is caused by pressure in front of or behind the neck, against the trochanter, or upward at the knee or ankle; but sometimes the limb can be pressed quite forcibly upward without causing pain. If eversion of the foot is absent, it will nevertheless be found that passive inversion is less complete than normal. Occasionally the foot is fixed in inversion. Pressure over the front of the neck shows that the tissues are less depressible than on the other side—a valuable sign in obscure cases. On gentle rotation of the limb the trochanter is found to share in the movement, and occasionally crepitus is felt.

Measurement (in making which care must be taken to place the limbs symmetrically with reference to the pelvis, as mentioned on page 284) shows the injured limb to be shorter than its fellow, the difference varying between a small fraction of an inch and two inches. This is best done by marking the site of the spines with an aniline pencil, and then measuring from the fixed malleolus to the mark over spine without touching the skin at the latter point. Similarly, the trochanter is found to occupy a higher position than its fellow with reference to a line drawn across it from the anterior superior spinous process of the ilium to the tuberosity of the ischium (Nélaton's line) (Fig. 101). If a line be drawn through the two anterior superior spines, and the distance from the summits of the trochanters to this line be measured, it will be found shorter on the injured side (Bryant's line) (Fig. 101).

A C D, Bryant's Ilio-femoral Triangle; A B, Nélaton's Line (Owen).



The **diagnosis** between the two varieties cannot always be made with certainty: a positive sign of fracture at the base of the neck is enlargement of the trochanter, due to its splitting; and it is thought that in fracture of the small part of the neck the shortening is more likely to be slight

at first and to increase suddenly and rapidly during the first few days from separation of the interlocked fragments. The opinion once very widely held, and even now occasionally encountered, that the differential diagnosis can be made by consideration of the age of the patient (intracapsular fractures in those more than sixty years old) or of the way in which the violence was received (intracapsular by a fall on the knee or foot, extracapsular by a fall upon the trochanter) has proved to be wholly untrustworthy.

It may even be impossible to say with certainty that a fracture is present, but in any case in which an *elderly* person, especially a woman, has fallen and complains of *pain* at the hip, with *inability* to use the limb, a fracture is probable, and the case should be treated as such for at least three weeks and until all pain and soreness have ceased. It has happened, often enough to justify great caution in giving an opinion, that the positive signs of fracture have not appeared until after a number of days, perhaps after the patient has been assured that he has suffered no serious injury and has been encouraged to use the limb. In not a few cases the patient has remained disabled long after the surgeon has ceased his attendance, and has sued the latter for malpractice.

The indications for **treatment** are, in the order of their importance, in the case of the old and feeble, to guard against the danger to the life of the patient arising from the traumatism and the necessary confinement, to secure firm union, and to have the minimum of deformity. The vital indication requires that the patient's strength should not be further taxed by dressings that cause pain or by prolonged confinement to bed if its ill effects become manifest and threaten to become serious. In the latter case, if necessary, union of the fracture must be sacrificed to the preservation of life. Special attention must be given to securing comfort and good nourishment and to the avoidance of bed-sores. Local treatment is limited to making only so much reduction of the shortening as can be effected by moderate traction, and to immobilization by traction and cushions or by a fixed dressing. Complete removal of the shortening is liable to break up an impaction that would be valuable in securing union. Traction by Buck's extension (Fig. 80) with a weight of five, or at most ten, pounds prevents further shortening and promotes comfort, and small firm cushions or sand-bags placed behind the trochanter and along the outer side of the thigh aid the immobilization. Hodgen's suspended splint (Fig. 84) is even better than Buck's. For immobilization without permanent traction either a long side-splint, extending from the side of the chest to the foot, or a plaster-of-Paris dressing, including the entire limb and the pelvis, may be employed. Lateral pressure in non-impacted fractures is of great importance in securing bony union, and on this account Senn recommends with the latter dressing the use of direct pressure inward against the trochanter, made through a fenestra by a pad at the end of a screw that passes through an iron support imbedded in the plaster. A well-applied plaster dressing appears to meet the indication sufficiently well. The dressing should be worn for about two months if the patient's condition permits.

It is to be expected that some shortening and outward rotation of the limb will persist; and the range of motion of the joint may be considerably restricted by the consequences of the arthritis or by an exuberant callus. Even if union fails or is fibrous, the patient may still be able to make fair use of the limb, the support being given by the Y-ligament, which secures a bearing against the ilium in the ascent of the shaft. In a few cases in which union has failed and the disability has been great and the condition painful, operations have been done to obtain union by freshening the surfaces and suturing or pinning the fragments together, or to remove the detached head.

Fracture of the great trochanter has been occasionally caused by direct external violence. The patients have usually been able to walk notwithstanding the injury. In the specimens obtained after death the fracture has always been found to be entirely outside the joint. The fragment may be large or small, and in the young may comprise the entire trochanteric epiphysis, separated along the conjugal cartilage. The *diagnosis* must be made on the independent mobility of the fragment and localized pain. The *treatment* is rest, aided perhaps by a bandage to oppose the retraction of the fragment upward and backward by muscular action.

Fracture of the shaft may be caused by direct or indirect violence or by muscular action. All the varieties of fracture of the shafts of long bones are found here, but the commonest is oblique fracture, often with the splitting off of a lateral piece, and with either or both main fragments ending in a long sharp point: transverse fracture appears to be quite common in children.

Symptoms.—Angular displacement and overriding are greatly favored by the contraction of the muscles, both those connecting the lower fragment with the pelvis and those that flex and abduct the upper one. Outward rotation of the lower fragment may be produced by the unsupported weight of the foot, which turns to the outer side; outward rotation of the upper fragment may be caused in like manner by the unsupported weight of the upper and outer portion of the thigh, the foot being meanwhile held upright. The latter displacement is equivalent to inward rotation of the lower fragment, and when the patient begins to walk he finds that the toes turn in. Compound fracture and associated injury to the large vessels are infrequent. Distention of the knee-joint by an effusion immediately after the injury is the rule, and is probably due to a concomitant sprain.

The *diagnosis* is made by pain, loss of function, shortening, abnormal mobility, and crepitus. Measurement is made, as in fracture of the neck of the femur, from either the malleolus or the knee to the anterior superior spine of the ilium, and the same precautions are needed to ensure symmetry of position. The fact that the shortening has occurred in the shaft, and not in the neck, is shown by the normal relation of the trochanter to Nélaton's line. Abnormal mobility can be recognized by passing the hand under the limb at the suspected point and gently raising it, or by grasping the upper part of the thigh firmly and moving the foot inward and outward, or by observing that the trochanter does not share in gentle rotatory movements communicated to the lower portion of the limb. Steady traction overcomes or diminishes the shortening. The thickness of the overlying muscles usually prevents recognition of the details of the fracture and displacement. Sometimes the sharp end of one fragment perforates the muscles and the skin, commonly the upper fragment in front; the penetration can be relieved by flexing the thigh upon the pelvis and the leg upon the thigh, the movement drawing the muscle down past the fragment.

Treatment is commonly by one of the methods of continuous traction, Buck's extension by weight and pulley (Fig. 80) or suspension by Hodggen's (Fig. 84) or N. R. Smith's anterior splint (Fig. 83) in adults, or vertical suspension in infants and young children. Hodggen's splint is especially useful in compound fractures, because of the facility with which it permits the dressings of the wound to be changed. The methods of applying Buck's extension and the suspended splints have been already described. The plaster-of-Paris dressing, including the pelvis, is still in use, but its results are not so satisfactory as those obtained by the other methods. Vertical suspension in young children is very useful, because of the ease with which the position can be maintained

and the child kept clean. The suspension is made by two india-rubber cords attached to a cross-bar above the bed and one to each leg by adhesive plaster, as in Buck's extension; the limbs are kept parallel by attaching the feet to a short foot-piece. The traction should be just sufficient to raise the buttocks slightly from the bed.

Union is complete in the adult in from six to eight weeks; in young children, in three or four. It is advisable to keep the patient in bed for a week after the dressings have been removed, and to insist upon the use of crutches for a week or two thereafter. Usually some shortening persists.

Fractures at the Lower End of the Femur.—In this group are included the supracondylar, intercondyloid, fracture of either condyle, and separation of the epiphysis.

Supracondyloid fracture is commonly produced by indirect violence, as a fall upon the feet; the line of fracture is oblique or transverse; and the usual displacement is of the lower fragment backward. Flexion of the lower fragment upon the tibia by the action of the gastrocnemii, by which its fractured surface is directed somewhat backward, occasionally occurs, but is by no means so frequent as has been alleged. A dangerous complication is sometimes found in rupture or stretching of the popliteal vessels. The *diagnosis* is easily made by recognition of the common signs of fracture. *Treatment* is by the plaster-of-Paris dressing or by suspension in Hodgen's or Smith's anterior splint.

Separation of the epiphysis is commonly caused by torsion or hyperextension of the leg. The *treatment* is the same as in the preceding variety.

In **intercondyloid fracture** (Fig. 102) the condyles are separated from the shaft and from each other. It is caused by great violence, as in a fall from a height, and is consequently often compound and accompanied with much displacement. It is always a serious injury, and if compound, a grave one. Continuous traction by Buck's extension or a suspended splint is advisable for the first two or three weeks, after which, if all is going well, the limb can be put in plaster. If compound, it is, of course, to be treated antiseptically.

Fracture of either condyle may be caused by direct violence, as in a fall upon the flexed knee, or by lateral flexion of the leg: the line of fracture runs from the intercondyloid notch more or less obliquely upward. The fragment remains attached to the tibia by its lateral ligament, and the displacement is therefore usually slight, although the fragment is sometimes carried forward or backward by rotation of the leg. The *course* is usually simple and the result good, but in a few cases suppuration of the joint or necrosis of the fragment has followed. The *diagnosis* is made by the recognition of abnormal mobility and crepitus; sometimes the only sign is localized pain on pressure, or on lateral flexion of the leg toward the injured side. The *treatment* is reduction of the displacement, if any, by bringing the leg to its proper position in full extension, and immobilization, preferably in plaster.

Fracture of the patella is an injury of frequent occurrence between the ages of twenty and fifty years, especially in males. It is usually the result of muscular action, but sometimes of direct violence, and sometimes of forcible flexion of the partially stiff knee when the descent of the patella is prevented by adhesions; the latter is the common method of production of refracture. Dull pain is occasionally felt in the patella for some days before

FIG. 102.



Intercondyloid Fracture of Femur (Bryant).

it breaks. Simultaneous fracture of both patellæ has been reported a number of times.

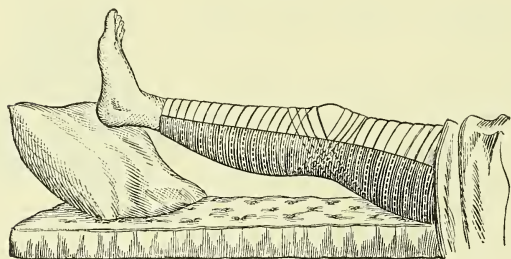
The *line of fracture* is almost always transverse, and, while generally near the middle of the bone, may be close to either end; exceptionally it may be oblique. In fractures by direct violence it is more or less comminuted, and is likely to be compound, or to become so by the sloughing of the bruised skin. The upper fragment is drawn upward by the quadriceps to a greater or lesser distance, but in some cases, and especially in fractures by direct violence, so much of the periosteum remains untorn that the separation is very slight. As a rule, the periosteum ruptures at a different level from that of the fracture, and thus is produced a narrow fringe which lies between the fragments when they are approximated, and to which much importance has been attributed as a cause of failure of bony union. The capsule is torn transversely on each side to a distance that varies with the separation, and the cavity of the joint promptly fills with blood and synovia, which still further increase the separation by distention.

The *symptoms* are loss of the power of active extension of the leg, independent lateral mobility of the fragments, and usually a distinct transverse gap between them which can be closed by pressing them together.

The *treatment* is immobilization of the extended knee for about two months, usually combined with dressings arranged to keep the fragments in contact with

each other. When the periosteal covering is not torn and the separation is slight, a plaster-of-Paris dressing, extending from the ankle to the upper third of the thigh, is sufficient, but in other cases special dressings are needed. Of these the variety is great. The simplest form consists of turns of a roller bandage, with a long posterior splint, applied obliquely above and below

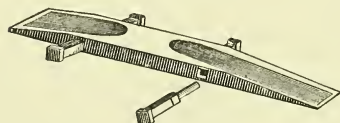
FIG. 103.



Hamilton's Dressing for Fracture of the Patella. The final turns of the roller in front of the knee are not shown in the cut.

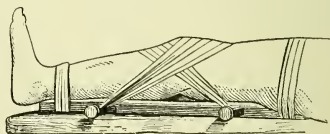
the fragments, so as to press and hold them together (Fig. 103); the patient should be kept in bed with the foot raised. Agnew's splint (Fig. 104) consists of a piece of pine board thirty inches long, five inches wide at the top, and four at the lower end, with four lateral pegs. Fig. 105 shows the manner of its appli-

FIG. 104.



Agnew's Splint for Fractured Patella.

FIG. 105.

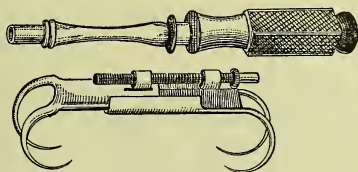


Agnew's Splint Applied.

cation, the fragments of the fractured patella being drawn together by the adhesive plaster strips. Another method is by elastic traction applied to the upper fragment: a piece of rubber tubing is made fast to each end of a strip of adhesive plaster about eight inches long and two inches wide; the adhesive plaster is then placed transversely close above the upper fragment, and the rubber cords

are stretched down on each side of the leg and made fast to the posterior splint. Malgaigne's hooks (Fig. 106) are used by forcing one through the skin into the upper border of the upper fragment, the other into the lower border of the lower fragment, and then bringing them together by means of the screw. Treves employs them after a preliminary exposure and freshening of the fragments, as in the operation of suturing, over which he thinks this procedure has some advantages. In any of these methods the effusion in the joint may often be promptly removed by the use of a rubber bandage, or the joint may be primarily emptied by aspiration of its contents.

Fig. 106.



Malgaigne's Hooks.

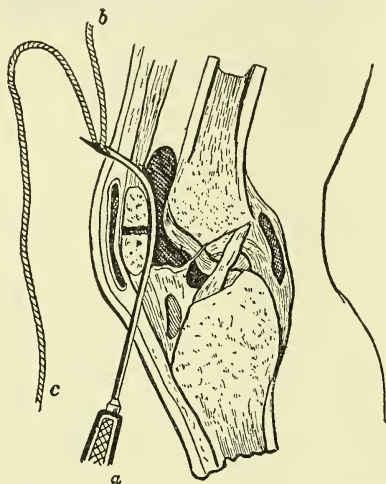
Operative measures include various forms of suture. The first to be employed was an open arthrotomy with direct suturing of the fragments with silver wire: it has given many brilliant successes, but also cases of suppuration of the joint, some with loss of the limb or loss of life—a risk which, in the opinion of some surgeons, the nature of the injury rarely justifies. The operation should only be done under strict antisepsis and in healthy subjects. In compound fractures it is not only permissible, but is often clearly indicated. The operation is done by exposing the fragments, freshening the fractured surfaces if the fracture is an old one, or dissecting away the fibrous tissue and fragments of periosteum or synovial membrane often found interposed, and drilling the bones in the median line, the drill-holes running obliquely from the anterior surface of the attached border of each fragment toward the posterior edges of the fractured surfaces. Silver wire is then introduced and the fragments are approximated, the wire being cut short and the ends hammered into the bone, or else left to protrude from the wound to be withdrawn later.

The substitution of a silk ligature through the tendon of the quadriceps and the ligamentum patellæ for the wire suture through the bone is preferred by some. The joint must not be invaded by the ligature. An antiseptic dressing is applied, and the limb kept on a posterior splint for a week. If all has then gone well, a plaster-of-Paris dressing is applied and worn for a month; after that, for another month it is worn only in the daytime and removed at night. The silk should be boiled and all antiseptic rules should be most rigidly followed; if suppuration occurs, free exit should be promptly given to the pus, to diminish the risk of invasion of the joint. The ligature may be employed subcutaneously by means of a long, slightly-curved needle introduced and brought out in turn through four small incisions, two above and two below the patella, or, better (Stimson), through a longitudinal median incision four or five inches long, fully exposing the bone and the tendons. After the joint has been emptied and the fringe, if present, raised from the broken surface, the silk ligature is passed by means of a curved needle transversely through the tendon of the quadriceps and the ligamentum patella close to the bone, drawn tightly to bring the broken surfaces into contact, tied and cut short. The fibrous layers between it and the patella should be smoothed out, and, when necessary, catgut sutures applied to close the lateral rents in the capsule.

Among other methods that have been recommended may be mentioned subcutaneous longitudinal drilling of the fragments and the use of a silver suture; transverse drilling of each fragment, the drills being left in place and

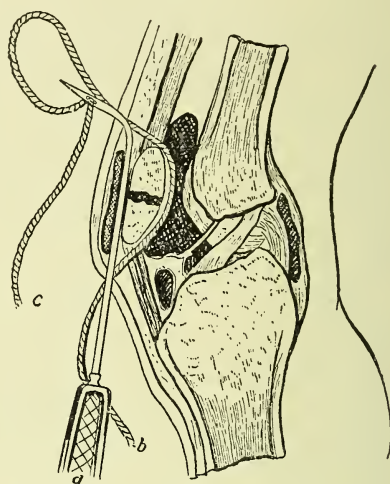
tied together on each side. Barker's operation (Figs. 107, 108), which has found much favor with many surgeons, is done as follows: The lower fragment of the

FIG. 107.



Barker's Operation for Transverse Fracture of the Patella (first stage).

FIG. 108.



Barker's Operation for Transverse Fracture of the Patella (second stage).

patella is steadied by the finger and thumb, and a narrow-bladed knife thrust into the joint, edge upward, in the middle line of the ligamentum patellæ at its attachment to the lower fragment. Through the wound thus made a stout-handled pedicle needle is thrust into the joint behind the lower fragment, and pushed up behind the upper fragment and through the quadriceps tendon in the middle line as close to the border of the bone as possible, the upper fragment at this time being forced down and steadied. When the point of the needle becomes apparent beneath the skin, the latter is drawn upward and an incision made upon the needle, the eye of which is then threaded with sterilized silk and the needle withdrawn, carrying the thread behind the fragments. The needle is next unthreaded and passed through the same skin wound below and out of the upper wound, but this time in front of and close to both fragments. Here it is threaded with the upper end of the suture and withdrawn. The two fragments are then brought together, friction is made to displace clots or other foreign material, and the ligature tied tightly over the lower border of the patella. The two ends of the ligature are cut short and the wounds closed. Union of the skin-wound is by first intention. Passive motion is begun on the tenth day.

Union is almost invariably fibrous in cases treated without the suture, and the bond of union habitually lengthens somewhat under use, but this does not materially affect the usefulness of the limb. In cases treated by the suture the union is closer, and may occasionally be bony.

Rupture of the bond or *refracture* of the bone at another point occasionally happens: the common cause is forcible flexion of the knee, in which the upper fragment is prevented from moving by adhesions that unite it to the femur or by shortening of the capsule on each side, which does not allow it to pass below the condyles. The injury may become compound by rupture of the adherent skin along the line of fracture.

In old cases, in which the disability is great because of the wide separation

of the fragments, open arthrotomy with suture has been done many times. Since modern aseptic methods have come into use, the proportion of successful cases has been much larger than formerly.

FRACTURES OF THE LEG.

Fractures at the Upper End.—The tibia may be broken at its upper end by direct or indirect violence, and the fibula may be simultaneously broken or its upper end dislocated, or it may be uninjured. The fracture may be transverse, oblique, or comminuted and impacted, or the line may run from the side of the head into the joint, separating only one condyle, or it may follow the epiphyseal line (separation of the epiphysis). In fractures by direct violence, usually by a heavy blow upon the front of the bone, there may be marked angular *displacement*, the apex directed backward, or backward displacement of the lower fragment, with the possibility of serious injury to the main vessels. In fracture by a fall upon the feet the lower fragment is driven into the upper one, splitting it and opening the joint. When the fibula is neither broken nor dislocated, displacement of the tibia is slight. The prognosis is serious because of the probability of implication of the joint in the inflammatory reaction, and it has been noted that repair of the fracture takes an exceptionally long time. After separation of the epiphysis the growth of the bone may be arrested.

The *treatment* consists in the reduction of the displacement, and in extension by continuous traction, or by splints, according to circumstances.

Fracture of the Upper End of the Fibula may be caused by muscular action (vigorous contraction of the biceps), by forced adduction of the leg, or by direct violence. The fragment may remain in place or may be drawn upward by the biceps. In several cases the external popliteal nerve has been injured, either in the accident or in the process of repair, with consequent paralysis of the anterior and peroneal groups of muscles. The *treatment* is immobilization, with the knee flexed to relax the biceps.

Fracture of the Shaft may be caused by direct or indirect violence, and in the latter case is more frequently situated at or near the junction of the middle and lower thirds. It may be transverse, oblique, V-shaped, or comminuted, and is frequently compound, either by the direct action of the violence upon the overlying soft parts or by perforation of the skin by the sharp end of one of the fragments, especially the upper one. When both bones are broken the fracture of the tibia is commonly at a lower level than that of the fibula. The common *displacement* is angular with overriding, the lower end of the upper fragment being displaced forward. The injury can be readily recognized by palpation of the subcutaneous surface of the tibia; abnormal mobility, which is greater when both bones are broken; and crepitus. Fracture of the fibula alone is shown by localized pain, and sometimes by abnormal mobility.

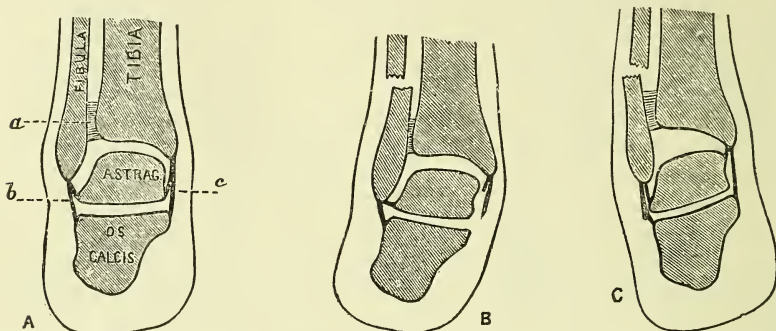
Treatment.—After reduction by traction and coaptation the limb may be secured by lateral splints or in a Volkmann splint or fracture-box for a few days until the swelling shall have subsided, and then in a plaster-of-Paris dressing, or it may be secured at once in moulded plaster-of-Paris splints, posterior and lateral. Care must be taken to prevent angular displacement by the sinking of the foot, and it is always advisable to remove the dressings and inspect the fracture after the first fortnight, when it is still possible to correct angular displacement. Union commonly takes place in about six weeks, but sometimes is long delayed.

Compound fractures should be dressed in accordance with general principles, and the limb placed in a fracture-box or Volkmann splint; if the

fracture has not become simple by the end of the first fortnight, interrupted plaster splints arranged for suspension will be found convenient. Delayed union and failure of union are not uncommon if there has been much loss of substance of the tibia by splintering; and if the fibula has maintained its length a piece should be cut from it in order that the fragments of the tibia may be brought together.

Fractures at the Lower End.—Of these the most common and important is the one known as **Pott's fracture** at the ankle, which is caused by

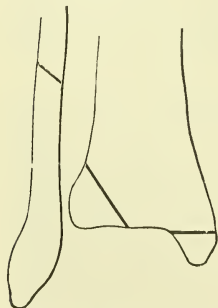
FIG. 109.



Diagrams to Illustrate the Mechanism involved in Fracture of the Lower End of the Fibula: A, parts in normal position: a, tibio-fibular ligament; b, external lateral ligament; c, internal lateral ligament; B, fracture of fibula due to eversion of foot; C, fracture of fibula due to inversion of foot (Treves).

forcible eversion and abduction of the foot; rarely by inversion and adduction of the foot. Fig. 109 shows the mechanism of both varieties. In a typical case there are three separate lines of fracture (Fig. 110): one of the fibula about three inches above the tip of the malleolus, and commonly extending obliquely downward for an inch or more; one of the internal malleolus; and one of the outer lower edge of the tibia; but in the place of the last two there is often rupture of the internal lateral ligament of the ankle and of the ligaments of the lower tibio-fibular articulation respectively. The essential feature of the injury is the separation of the external malleolus from the tibia and its displacement outward in company with the foot. When the injury is caused by pure eversion of the sole the fibula is broken less obliquely and the internal malleolus is broken square across; when abduction of the front of the foot is associated with eversion, the fracture of the fibula is more oblique and rupture of the internal lateral ligament is much more frequent than fracture of the internal malleolus; if the latter occurs, it is oblique, the anterior portion only being broken off.

FIG. 110.



Usual Three Lines of Fracture in Pott's Fracture at the Ankle (Stimson).

The *symptoms* are the characteristic deformity (Figs. 111, 112), consisting in outward displacement of the foot and prominence of the internal malleolus, the existence of three points of localized pain on pressure corresponding to the three lines of fracture or the equivalent injuries, and the possibility of moving the foot from side to side within the widened tibio-fibular mortise. Occasionally the (broken) internal malleolus is forced through the skin and the joint thus opened, or if the displacement remains unreduced the skin overlying the malleolus may slough in consequence of the pressure. The foot has a decided tendency to slip backward, sometimes

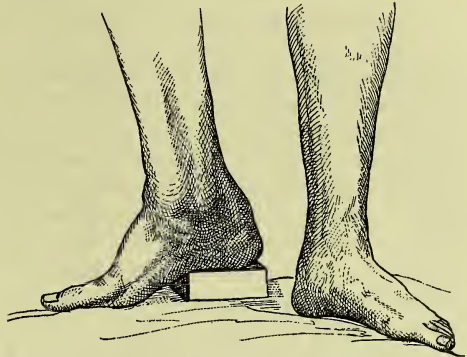
so far that the body of the astragalus lies entirely behind the tibia; and this displacement is frequently overlooked.

The essential point in *treatment* is to reduce the displacement completely and prevent its recurrence; the former is easy, and so too is the latter if suit-

FIG. 111.



FIG. 112.



Pott's Fracture, showing Outward Displacement. Pott's Fracture, showing also Backward Displacement.

able dressings are used, but each requires close attention and full appreciation of the needs. Reduction is made by grasping the leg firmly with one hand and the foot with the other, and then, after lifting the latter forward, pressing it forcibly inward until the external malleolus is felt to rest against the tibia. An efficient dressing is made of moulded plaster-of-Paris splints, one of which is placed posteriorly from just below the knee, along the calf, the heel, and the sole, to and beyond the toes; the other begins on the dorsum of the foot, crosses the outer border and the sole, and is carried up the inner side of the leg; circular turns are placed above the ankle and at the upper ends of the splints. It is advisable to invert the sole of the foot, in order to make sure that the lateral reduction is complete. While the splints are hardening the foot must be held in place by the surgeon or by an assistant who appreciates the necessity and the means of maintaining the reduction, both inward and forward. This dressing is to be preferred to complete encasement in plaster, because it permits inspection of the region. Good results can also be obtained, though with less security, by the use of an internal lateral splint (Dupuytren's splint) projecting below the foot. A wedge-shaped pad is placed between this splint and the leg, the base of the wedge being just above the internal malleolus. The foot is then secured to this internal splint in adduction. Great care must be taken to protect the skin from too great pressure.

Fracture of the External Malleolus is caused by an inward twist of the foot, by which the astragalus is so turned in its mortice as to force the malleolus outward and break it. The line of fracture is lower than in Pott's fracture, and lies within the lowest inch or inch and a half; sometimes separation of the fibula from the tibia at the lower tibio-fibular articulation is produced instead of fracture, as shown by pain on pressure over the front of the joint; and, much more rarely, the tip of the internal malleolus is sometimes broken off by the pressure of the astragalus against it in the same twist of the foot. The diagnosis of the fracture of the fibula is made by local tenderness on pressure at its seat and on twisting the foot inward, and possibly by abnormal mobility

recognized by pressure inward against the tip of the malleolus; it is supported by the history of the accident and the appearance by the second or third day of an ecchymosis below the malleolus. No treatment is needed except rest and the support of a dressing to prevent the occurrence of another twist of the foot.

FRACTURES OF THE BONES OF THE FOOT.

The **astragalus** may be broken by a fall upon the foot, the line of fracture passing through the body or the neck, and the injury is frequently associated with dislocation of one of the fragments. An exact diagnosis may be difficult or impossible except when dislocation is present. The choice of treatment lies between immobilization and removal of one or both fragments; the latter is obligatory when the fracture is compound or when the associated dislocation is such that the skin will slough or that the subsequent disability will be great. The functional results after removal of the astragalus are very good.

The **calcaneum** may be broken by a fall upon the foot or by forcible contraction of the muscles attached to the tendo Achillis. In the latter case a larger or smaller posterior fragment is torn off and may be displaced upward; the treatment is immobilization with the knee and ankle so flexed as to relax the calf-muscles. Fractures due to a fall are usually comminuted, with depression of the central part of the bone; the diagnosis must be made upon the flattening and broadening of the sole and heel (which can be best seen by making the patient kneel and then comparing the soles of the two feet), and by the relaxation of the tendo Achillis. The treatment is by massage and immobilization, but the patient should be encouraged to use the limb as soon as possible.

Fracture of the Metatarsal Bones is commonly caused by direct violence, and is frequently compound; the first and fifth are the most frequently broken. The diagnosis is made by pain on pressure at the seat of fracture or on pressing the corresponding toe directly backward, and by abnormal mobility in the case of the first and fifth or when several toes are broken. In simple cases no treatment is required except rest, with the foot elevated, and massage.

CHAPTER IV.

DISEASES AND INJURIES OF THE MUSCLES, TENDONS, AND BURSÆ.

SECTION I.—DISEASES AND INJURIES OF THE MUSCLES.

THE muscles, with very few exceptions, are situated beneath the external layer of the deep fascia. By virtue of their contractility they bind together and move the parts of the skeleton, contract and compress organs to which they are attached, and aid in the protection of vessels and nerves, and of the viscera in the great cavities. Their essential sarcoous elements are held in place and maintained in proper relation by connective-tissue investments; their power is transmitted through inelastic fibrous bands—the tendons—in part inserted into the bones, in part blending with the periosteum or the great fascial planes. Like other structures, they are at times the seat of disease and injury, though much less frequently than might be thought probable from their number, size, and location.

MYALGIA.—Pain located in a muscle, and to a greater or less extent preventing its use, is of very frequent occurrence, and depends upon the action of many causes, such as strain, twist, or slight laceration of the fibres, acute infectious disease, poisoning, as by lead or syphilis, etc. Muscle-pain is the one common symptom. In the majority of cases it is neuralgic, but may at times be inflammatory. It is easily diagnosticated, and usually quickly subsides, either spontaneously or in consequence of the employment of heat, electricity, anodynes, or anesthetics; or it disappears with the removal of the exciting cause.

RUPTURE.—Blows from without or undue and sudden unopposed contraction may cause laceration, varying in degree from a tear so slight as not to be distinguishable from simple stretching to a complete pulpification; and in result from speedy and perfect recovery to destruction of the part or even to loss of life. Spontaneous rupture of healthy muscle can occur only when the contraction is sudden, unexpected, or of unusual character, as in the “lawn-tennis leg” or “arm” of those unaccustomed to that form of exercise. But when, in consequence of disease, especially typhoid fever, and, much less frequently, scarlet fever, yellow fever, or other acute grave pyrexia, the fibers have undergone granular or vitreous degeneration, their extreme brittleness makes it possible for rupture to follow voluntary movement of slight extent. The rectus abdominis, the rectus femoris, the adductors of the thigh, the calf muscles, the psoas, and the flexors of the forearm are those most frequently affected, and in the order given. Except in cases of laceration occurring in the progress of general diseases, the occurrence of rupture is generally indicated by a sudden sharp pain, accompanied with the sensation of snapping or of the “giving way” of something in the injured region, by a well-marked depression or a wide gap at the seat of injury, and by extravasation of blood, with the subsequent color-changes in the skin. The ability to use the muscle is either wholly or in great measure lost. Complete recovery may be expected when the laceration is but slight, and even when quite extensive the ultimate damage may not be great. When the abdominal muscles are the ones injured, intestinal obstruction, simulating strangulated hernia or peritonitis, may be developed.

In the **treatment** of these injuries the chief reliance must generally be placed upon rest and the approximation of the edges of the laceration by position and due compression. In rupture of healthy muscle sutures may advantageously be employed, but are of little or no value when the muscle has undergone degenerative changes, since the stitches will ordinarily quickly tear out.

HERNIA OF MUSCLE.—Occasionally, in consequence of the imperfect healing of a wound of the overlying deep fascia, limited protrusion of the muscle is observed to take place, with resulting impairment of muscular power. Such a hernia is readily recognized by the marked fulness in the region at the time of muscular contraction, disappearing when relaxation occurs, and by the detection of an opening in the aponeurosis, the rounded edges of which may readily be felt through the skin. In recent cases rest and methodical pressure will generally effect a cure. When the hernia has long existed the edges of the opening should be freshened and united by stitches. If, as is often the case, the inconvenience resulting from the presence of the hernia is but slight, the wearing of a bandage may be all that will be required.

MYOSITIS.—Muscle inflammation is almost always due to traumatism, to contiguous inflammation, to diathetic states, or to the presence of parasites. If consequent upon injury, it is usually a matter of but little importance in comparison with the other conditions dependent upon the traumatism. Sup-

putation rarely takes place unless the injury be of the psoas muscle, and when it does occur is usually followed by recovery. Occasionally, and especially in badly-nourished individuals, there occurs a diffused inflammation of great severity, almost always of septic origin, in which the affected muscle quickly breaks down, the patient generally dying speedily of septicemia. Only rarely can it be cut short by early free incision.

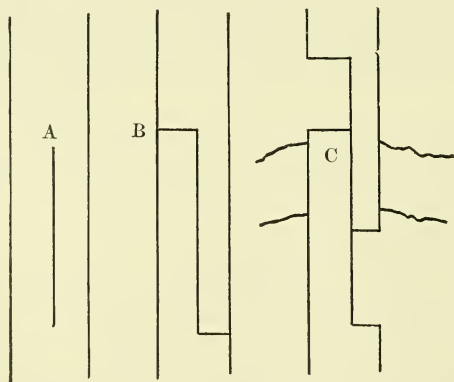
So-called rheumatic myositis (*myositis a frigore*, muscular rheumatism) often affects the muscles of the back, the chest, or the neck, and is generally attributed to sudden chilling of an exposed part. It is probably, in the great majority of cases, not an inflammation at all, but the result of a sprain or a twist of the muscle, the symptoms and treatment being those of myalgia.

During the course of a gonorrhea myositis has occasionally been observed, generally in the muscles in relation with an inflamed elbow or knee, such inflammation differing from the ordinary one only in its cause, which is probably a mild sapremia.

Unless associated with joint or bone disease, a slowly-developed chronic myositis is almost always syphilitic in origin. Generally in these cases the affected part is so much indurated that the hardness has been characterized as "woody." An exceedingly annoying myositis of the sphincter ani has been observed in syphilitics, in women more often than in men.

CONTRACTURES. (See also Orthopedic Surgery.)—Persistent shortening of a muscle—that is, the fixed approximation, more or less, of its points of origin and insertion, with resulting change in the position of the parts to which it is attached—may be due to the action of very many causes. Among these may be mentioned loss of substance, intra- or extra-muscular, followed by cicatricial contraction; inflammation, either traumatic, infective, specific, or toxic; contiguous bone or joint disease, with associated deviation from pathological causes

FIG. 113.



Anderson's Method of Lengthening a Tendon.

or from gravity; weakened action of its proper antagonist; paralysis, with resulting connective-tissue sclerosis, due to a central lesion, either cerebral or spinal; reflex irritation from local injury, with or without retention of a foreign body; or it may be but a symptom of a general nervous affection, hysteria, chorea, etc.

As ordinarily met with in non-traumatic cases, it is associated with disease of the cord or brain, with infantile paralysis in children, or, much more rarely, with cerebral paralysis and intracranial hemorrhage in adults. In the former it is of

late appearance, and is observed most commonly in the legs, chiefly because of diminished resistance by opposing groups of muscles. In adults it is either early, transitory, variable, increased upon voluntary motion, absent or greatly lessened in sleep, and irritative in character; or late, degenerative, increasing, permanent, and especially affecting the upper extremity. The face and neck, occasionally also the lower extremities, may be contractured, but never so alone. It produces, as a rule, abnormal flexions in the upper extremity, but extension

at the knee and ankle; when, however, the contractions occur in connection with chronic spinal inflammation there is strong flexion at the hip and knee.

When it is due to or indicative of an inflammation of a neighboring joint and is developed early, it is protective in character, producing such fixation of the articulation as is likely to lessen the disease in it by affording rest. Not seldom when unassociated with joint disease or paralysis a contracture will be found to be of syphilitic origin; and this is especially true of that affecting the biceps cubiti.

Lately Anderson and several other surgeons have simultaneously proposed to lengthen tendons by a definite amount in cases of contracture. Fig. 107 shows very well how this is accomplished by splitting the tendon, sliding one end up or down, and then suturing the ends, thus securing a definite amount of lengthening of the tendon.

HYPERTROPHY.—The enlargement of a muscle may be real, the sarcous elements being increased in number or in size; or apparent, due to change in the amount of fat or connective tissue or to an overgrowth of the lymphatics and blood-vessels. It may be physiological and consequent upon increased action of the affected muscle, as in certain classes of workmen, or associated with pathological states, when, as in the enlarged heart or the thickened bladder, it may be compensatory, and therefore to some extent salutary. Lessened use of the part, or rest, aided by compression, may effect a reduction in size.

In adults there has occasionally been observed a progressive muscular hypertrophy affecting chiefly the upper extremity, as a rule on one side only, which is usually attended with lessened rather than increased functional strength.

ATROPHY.—Diminished size of muscles is of frequent occurrence, and may be due to disuse, to diseases of joints, to nerve-injury, to disease of the spine or the brain (rarely observed except when the pons is affected), or to a general depraved or poisoned state of the blood. As met with in connection with lesions of bones or joints, it is in great measure, if not wholly, due to reflex disturbance of the trophic nerves, and not to the enforced quietude of the affected part. Very often it is associated with degeneration, granular, pigmentary, fatty, or waxy, the latter two being the more common and the more important.

In the fatty degeneration there may be a substitution of fat for the true muscular elements, or, still oftener, for the connective tissue, occurring slowly and of limited extent, or, as in cases of phosphorus-poisoning, rapidly developed and largely generalized; or, as is much oftener the case, the fat may be present as an infiltration or accumulation in relation with the connective-tissue framework of the muscle. In the former, though the deposit may be absorbed and muscular redevelopment follow, there is generally permanent destruction of the affected fibers; while in the second either no effect is produced upon the contractile substance or it is affected only through pressure.

In certain of the acute infectious fevers, especially yellow fever and typhoid, in not a few cases of tetanus, and occasionally, though rarely, after nerve-injuries, the muscular elements appear as a transparent, waxy, very brittle mass which breaks up into cuboidal blocks, the connective tissue at the same time taking on increased growth. Pain, weakness, impaired function, and liability to rupture are the effects of this vitreous degeneration. It is always destructive to the affected fibers,—which may be few in number or may constitute the greater part or the whole of the muscle. In three diseases (progressive muscular

atrophy, pseudo-hypertrophic paralysis, and infantile paralysis) muscle atrophy is a strongly-marked symptom, of medical rather than surgical interest, except so far as resulting weakness and deformity, especially in infantile paralysis, necessitate the use of supporting and correcting mechanical appliances with or without operative interference.

OSSIFICATION.—Inflammation following long-continued irritation may result in the formation of bone in the belly of a muscle, or, as is more often the case, in its tendon, such, for example, as the bone-plates in muscles close to exuberant callus after a fracture, or as the so-called exercise or rider's bone, the latter being of not infrequent occurrence in the upper or lower tendon of the adductor magnus femoris. At times the ossification is of syphilitic origin. If it is in one of the superficial muscles, the bone-plate can readily be felt when near the attached end of the tendon, the only question being whether it is tendon, bone, or a true exostosis; but if deeply placed its existence remains undetected during life. To whatever cause it is due, the bony growth is permanent unless removed by operation. This may occasionally be rendered necessary by existing pain or impairment of function, which at times is consequent upon the size or location of the osseous mass.

A few cases have been observed of an early-commencing, slowly-advancing, general muscle inflammation, starting usually in the neck and back, in which after a time the atrophied parts become the seat of bone-formation, *myositis ossificans*, the cause of which is as yet undetermined. Generally very protracted in its course, it resists all treatment, death resulting from involvement of the respiratory muscles or from simple exhaustion.

TUMORS.—These may be either benign or malignant, located in the belly of the muscle or in its tendon. The majority of those which are not sarcomatous or carcinomatous are of syphilitic origin, the specific disease affecting any muscle, but particularly the sterno-cleido-mastoid and the biceps cubiti. The malignant tumors are very rarely primary. In an interesting, though fortunately seldom observed, class the developing cause is parasitic—*i. e.* the presence in the muscle of the echinococcus, the cysticercus, or the trichina. The **diagnosis** will be based upon the history of the case and the recognition of a more or less well-defined swelling intimately connected with the muscle or the tendon; in the parasitic form the microscopic examination of an excised portion of the tumor will establish the diagnosis. The **treatment** will depend upon the nature of the growth, which will either be left untouched or taken out of the muscle, or removed with the part in which it has grown.

WOUNDS.—These may be either subcutaneous or open wounds. The former are sometimes accidental, but usually operative; the latter are most frequently incised or lacerated. Hemorrhage and separation of the edges are the chief symptoms, the latter, of course, being much more marked in complete than in partial transverse section. If protected from septic infection, their gravity is very slight, and unless there has been extensive loss of substance the repair functionally is very good, union taking place ordinarily through the medium of a connective-tissue scar, though when the wound is small and its edges have been early and closely approximated true muscular regeneration may occur.

The **treatment** consists in securing close apposition and in the maintenance of rest. Incised wounds and lacerated and contused ones in which the parts can be brought together, after trimming of the torn edges if necessary, should be united with catgut or silk buried sutures rather than treated simply by strapping and bandaging, since, when sepsis is prevented, the stitches do not readily tear out, and a quicker, closer repair is secured.

SECTION II.—DISEASES AND INJURIES OF TENDONS.

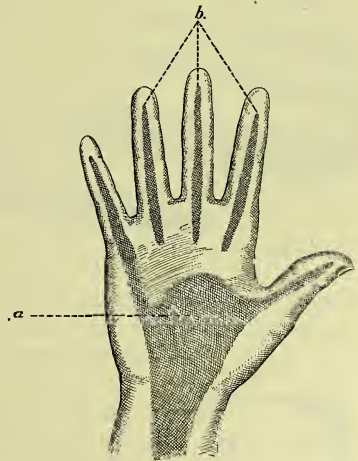
TENO-SYNOVITIS, OR THECITIS, AND PALMAR ABSCESS.—Inflammation of a tendon sheath may be either acute or chronic. The acute form is chiefly due to traumatism, and is suppurative or non-suppurative according to the presence or the absence of pyogenic microbes; the chronic form is of tubercular origin.

The *acute* form may follow a wound or a slight but frequently repeated contusion, as in certain classes of workmen, or it may result from a strain or be connected with rheumatism, syphilis, or gonorrhea. In the *non-suppurative* variety there are present pain and swelling along the course of the tendon, with early-developed crepitation, due to the rubbing of the exudation-lined surfaces. Such crackling disappears as the sheath becomes distended with fluid, to reappear again for a while as absorption takes place. The associated constitutional symptoms are ordinarily slight, except in cases of the special diseases mentioned, when they are those of such diseases. The duration of the affection varies, according to its severity and to the treatment, from a few days to three or four weeks, terminating commonly in complete recovery, though at times some dry crackling remains for a while. Rest and pressure by splint and bandage are usually all that is required in the way of *treatment*, though hot- or cold-water applications are often of service at first, and the use of the tincture of iodine is thought highly of by many. Opiates may be needed to relieve pain.

When the thecitis is *suppurative* the severity of the inflammation is great: unless free incision is promptly made, destruction of the sheath and its contained tendon will take place, often with wide extension of the disease along the tendon and in the neighboring connective tissue, followed, it may be, by general infection. The pain is intense and throbbing, the tenderness excessive, the swelling marked and rapidly developed, the overlying skin red, the constitutional symptoms of high grade. Elevation and rest of the part, as complete as possible, must be secured, and hot applications made; but the first and most imperative demand is for free opening of the sheath, curetting, and thorough antiseptic drainage and dressing. If, notwithstanding these measures, the supuration extends, other and more free incisions must be made, and thus destruction be limited as far as possible.

The disease often affects the flexor sheath of a finger, and, unless promptly arrested, **palmar abscess** is very likely to follow. This danger is much greater if the disease attacks the thumb or the little finger rather than the other three fingers, since, while the proximal closed end of the sheath in the index, middle, and ring fingers (Fig. 114 *b*) is separated from the cavity of the general synovial sheath of all the tendons in the palm (*a*) about half an inch, the sheaths of the thumb and the little finger communicate directly with it. Whether secondary to teno-synovitis of the finger, or primary and due to direct infection and inflammation of the palmar fascia and the connective tissue under it, it is a serious matter.

FIG. 114.

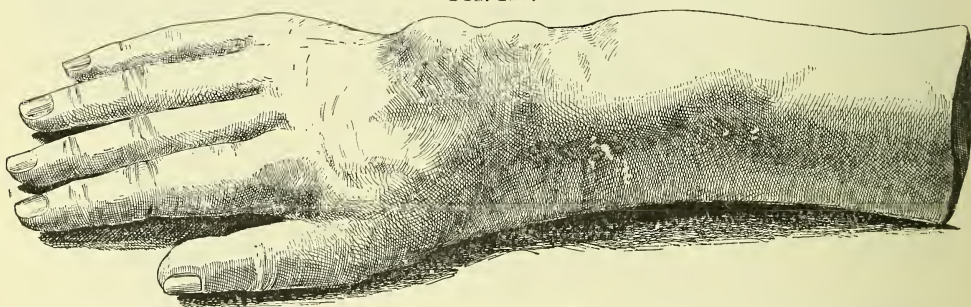


Synovial Sheaths of Flexor Tendons of Fingers: *a*, general sheath common to the tendons in the palm and those of the thumb and little finger; *b*, separate sheaths of the fore, middle, and ring fingers (original).

It may be limited or general, according to the intensity of the infection, and is indicated by the presence of symptoms similar to those already mentioned as characteristic of thecitis—pain, swelling, restrained at first by the firm fascia, high fever, etc. Frequently a small superficial serous or purulent effusion early shows itself in the palm, which has often been mistaken for the real affection, to the serious injury of the patient because of the resulting delay in freely laying open the parts. If untreated, or it may be in spite of treatment, the pus may pass between the bones to the dorsum of the hand or under the anterior annular ligament, upward beyond the palmar pouch into the connective tissue of the forearm, along the planes of which it may be carried to or even beyond the elbow. Here, again, free incision must be made in the line of a metacarpal bone and disinfection and drainage secured. The incision may be made fearlessly up to a line transverse to the web of the thumb, as the palmar arches both lie above this line. Beyond that the vessels should be avoided, or if divided *both* ends must be tied. At the best, some stiffness of the fingers and impairment of the functional value of the part not seldom results, and the hand is often “griffed” (claw-hand). Necrosis of the carpus may occur, necessitating, at times, amputation; there may be troublesome, even dangerous, hemorrhage from the vessels of the hand or forearm; and in a small proportion of cases death takes place because of exhaustion or septic infection.

Chronic teno-synovitis, as has been stated, is a tubercular disease, presenting itself either as a firm swelling (Fig. 115) consequent upon the presence of a thick mass of granulation-tissue in and upon the sheath; a more or less distinctly fluctuating swelling in which there is less deposit upon the walls, but fluid in considerable quantity in the cavity of the sac; or a similar swelling containing in addition small firm bodies resembling rice-kernels (*riziform*, or *melon-*

FIG. 115.



Chronic (Tubercular) Teno-synovitis or Thecitis of the Sheaths of the Extensor Tendons (original).

seed bodies, Fig. 116) attached to the walls or floating free. Tubercle bacilli in greater or less number are almost invariably present in each form of the affection.

FIG. 116.



Rice-kernel or Melon-seed Bodies from the same case (Fig. 115; original).

It is observed most frequently, indeed in nearly four-fifths of the cases, in the forearm. It may be developed in connection with any of the tendons, but especially those of the fingers and those in the vicinity of the knee and ankle. Though very slow in its course, particularly in the cystic varieties, its tendency is to extend upward and downward along the affected tendon (which in the fungous variety is invaded and in part or wholly destroyed), to attack other tendons in close proximity, and to pass into underlying joints. Frequently it is secondary to joint tuberculosis. As it is attended by little or no pain, for a long time it may cause

no material functional impairment. Very rarely it spontaneously disappears. The contents having broken down the sheath and escaped externally (and this is very much more common in the fungous variety), an ordinary tubercular abscess generally follows, the spontaneous or non-aseptic opening of which permits of infection by pyogenic organisms with resulting extensive suppuration.

The locality of the swelling, its more or less spindle shape, its slow course, and the little attendant inconvenience are the **diagnostic signs** of the disease in general; the degree of resistance to touch and the absence or presence of fluctuation, those of the variety, fungous or cystic; a peculiar crepitation elicited by pressure or upon movement indicates the presence of the riziform bodies. When located in the palm of the hand, affecting the several flexor tendons and extending up to the wrist, the swelling of this so-called "compound ganglion" is more or less hour-glass in shape because of the constriction made by the anterior annular ligament.

The **treatment** to be effective must be operative, by tapping and injection, by evacuation and scraping, or by excision. When there is but little thickening of the sheath and the contents of the sac are simply fluid, aspiration or limited incision, with injection of iodoform, will generally bring about a cure; when the melon-seed bodies are present the sheath must be laid open to such extent as to permit a complete evacuation and thorough scraping of the walls (in the palmar ganglion the annular ligament, if necessary, being divided and later reunited); when the case is fungous, relief can be afforded only by complete removal of all the infected tissue outside the sheath, in the sheath itself, and in the tendon. The parts should be rendered bloodless by the Esmarch bandage, so as to permit of the recognition and careful dissection of what must be taken away, and great care should be exercised to do as little damage as possible to contiguous healthy structures. If it becomes necessary to remove any considerable part of the tendon, much benefit will follow suturing to the upper end of the lower fragment a piece secured by splitting from the upper fragment and turned down. Relapses very often occur, and not seldom the patient ultimately dies of one form or other of visceral tuberculosis. In all operations for teno-synovitis and in the after-treatment it is of extreme importance to prevent sepsis, since pyogenic infection is very dangerous to the part and to life.

PARONYCHIA, WHITLOW, or FELON is an inflammation of a finger, rarely of a toe, consequent upon traumatism, usually of slight character; it may be but a scratch or prick or little abrasion, permitting of the entrance of septic germs. It may be of moderate or great severity according to the virulence of the organism and the general state and resisting power of the individual affected. It is more common upon the right than the left hand, and usually commences upon the last phalanx. It may be superficial or deep, in the latter case beginning as such or becoming so by extension from the under surface of the derm, favored in the pulp of the finger by the fibrous threads that tie it down to the bone.

The *superficial variety* is the more common and the least troublesome, affecting one finger or several in succession or at the same time, as is often the case in debilitated subjects, especially children, and located generally around and under the nail. The inflammation may be slight and subside quickly; or somewhat more severe, causing subepidermal serous or purulent effusions. The former is absorbed in a few hours or days; the latter is associated with ulceration, but soon heals, though often leaving a scar which is red and tender for some time. In much-enfeebled individuals the inflammation may be of a high grade, the pain intense, the swelling decided, the suppuration abundant, and may cause loss of

part or the whole of the nail and the development of fungous granulations, the disease often in neglected cases lasting for weeks or months until the necrosed nail is thrown off. The **treatment** varies with the severity of the inflammation. Rest and elevation of the part and cold applications are all that is required in the milder cases. The use of hot fomentations, simple or medicated, together with prompt and complete evacuation of the pus, is indicated when suppuration occurs. In the graver cases early incision and the administration of tonics and anodynes are necessary. Change of residence, if it can be effected, is useful. The nail must be removed as soon as it is evident that it must be lost, and iodoform, corrosive sublimate, carbolic acid, nitrate of lead, or other similar agent may be applied to the ulcerated surface.

The **deep whitlow** usually commences on the palmar aspect of the last phalanx, though it may originate in an injury of the second or first phalanx, or, more rarely, upon the dorsum. In a few hours it may be, or more commonly within a day or two, after the receipt of the injury, the finger becomes painful, tense, hot, and throbbing, with accompanying elevation of temperature and acceleration of pulse. These symptoms rapidly increase in severity, especially the pain and tension, and are both aggravated by the dependent position. Resolution rarely occurs, suppuration usually taking place. Associated with the deep collection of pus there is often a superficial abscess that may be mistaken for the real disease.

Though at times the application of cold, of the tincture of iodine, of carbolic acid, or of a blister has afforded relief, in the great majority of cases such **treatment** is of no value. Carbolic acid has been known to produce gangrene of the finger. So strong is the probability of the formation of pus, that it is better to employ hot antiseptic solutions or fomentations from the beginning, and if within two or at most three days decided improvement does not take place, free incision should be made—to the bone when it is the last phalanx that is affected, to the tendon when the first or second, since in the former locality the disease is almost certain to have gone down to the periosteum, while in the latter it very probably is as yet only a teno-synovitis, and the integrity of the tendon may be preserved by opening the sheath. The after-treatment should be thoroughly antiseptic. Often in spite of early incision and proper dressing necrosis of the last phalanx occurs. When it does, it is likely to stop at the epiphyseal line, and the dead bone can be removed later without opening the articulation. Necrosis of the second or first phalanx will generally necessitate amputation, though a tolerably useful finger may at times be secured by simple removal of the necrosed bone.

GANGLION.—Closely connected with a tendon, especially upon the back of the hand, there is often found a small round swelling, firm to the touch, at times almost as hard as bone, slowly developed as a rule, and causing little inconvenience except when in consequence of the occupation of the patient the tendon has been largely exercised. The contents of this swelling are a viscid honey-like fluid. At any period of its development the little swelling may disappear or cease to grow. Formerly regarded as a dropsy of the tendon sheath (hence a common name, “weeping sinew”), it is probably an outgrowth of the synovial follicles of these sheaths, more rarely of the synovial pouches or the subsynovial bodies of Henle, or perhaps it is a new growth, a colloid cyst, having nothing to do with the tendon sheath except that it lies in close apposition with it. It is **diagnosed** by its shape, location, and feel, and is to be **treated** by subcutaneous evacuation or by excision. Generally the former method is adopted, though refilling of the sac often occurs. By pressure of the thumb a thin-walled ganglion may be readily burst, and even a somewhat thick-walled

one, by a smart blow. Preferably, however, the sac should be subcutaneously divided by a small knife or spear-pointed needle, and the contents pressed out alongside the instrument or into the surrounding tissue, when rapid absorption ordinarily takes place. When the tumor is very hard or very large, or there have been several recurrences, excision should be done, the sac being freely exposed and carefully dissected off the tendon. Under proper antiseptic dressing primary union may be expected.

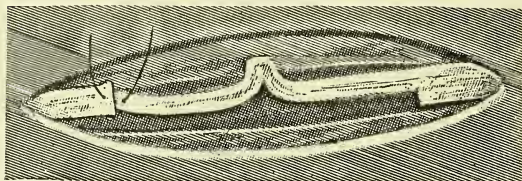
RUPTURE OF A TENDON.—Sudden violent efforts are at times followed by rupture of a tendon, indicated by a snap which may be both felt and heard, by pain, by cessation of the action of the associated muscle, and often by a fall when the tendon is in the lower extremity. A gap at the seat of injury, increased upon extension, may frequently be recognized on palpation, and a depression may be seen. At the knee there will soon be marked effusion into the joint, and if the ligamentum patellæ is ruptured the patella may be more or less displaced upward. The rupture may be complete or partial, generally the former. The tendon of the rectus femoris above or below the patella, or the tendo Achillis in the lower extremity, and those of the triceps or biceps in the arm, are the ones usually torn. The **treatment** consists sometimes of approximation by position of the separated ends as much as possible, and maintenance of the same by splints, bandages, or apparatus until reunion takes place, which commonly occurs in from four to eight weeks. Generally, however, the better method is by suture, especially when the existing gap is a wide one or the tendon is that of a muscle in which contraction can be controlled only imperfectly or with great difficulty. In the leg especially operation is indicated unless great age or other contraindication exists. The old-time objections to exposing and operating upon a tendon no longer hold good, since septic infection can very generally be prevented. This is especially important at the knee, as the joint may be opened at the operation.

WOUNDS OF TENDONS.—These are either punctured, subcutaneous, or open. The former are of no importance unless accompanied by the entrance of pyogenic organisms, when they may be very destructive from the inflammation of the tendon, its sheath, and the surrounding parts. Subcutaneous wounds, when complete, as in the operation of tenotomy, are attended with a snap and separation of the ends, causing the formation of a depression both seen and felt; they are accompanied ordinarily with but slight hemorrhage and little pain. Repair takes place readily without any decided local or general disturbance, the connective-tissue callus being shorter or longer according to the amount of approximation secured. When formal tenotomy is done apposition of the ends is not wanted, and by position considerable separation is maintained, the functional value of the part ultimately becoming nearly or quite perfect. Open wounds are dangerous or not according as they do or do not become infected. If aseptic, they are quickly recovered from, and modern experience has so clearly demonstrated this that to-day, by preference, most such operations are performed openly in cases in which until recently the greatest care was exercised to prevent any extensive division of the overlying soft parts. After operative tenotomy the **treatment** is by position and pressure. After accidental division, however, the treatment should invariably be by suture, the stitch being of buried catgut or silk. At the wrist, where several tendons may be simultaneously divided, care must be taken that the two ends of the same tendon are united.

Tendon-suture may be done also in old cases of rupture or wound, even when extensive dissection is required to find and free the widely-separated ends buried in it may be in a mass of scar tissue. If the freshened fragments

can be applied to each other, either end to end or overlapping, they should be stitched together, the sutures being drawn only sufficiently tight to maintain the apposition without making undue constriction of the included parts. If there has been too great loss of substance to permit such direct attachment, but the sheath ends can be united, this should be done, as redevelopment of the tendon will occur in the canal thus formed; or long catgut stitches may be used which will serve as a framework upon which the new formation can take place; or one of the pieces of the tendon may be longitudinally split for the necessary

FIG. 117.



Czerny's Method of Tendon-suture when the Ends cannot be Approximated.

distance nearly to the end, and the detached half turned down and united to the other part of the tendon, the ultimate result being the formation of a tendon sufficiently strong fully to perform its physiological function (Fig. 117). Where this cannot be done, transplantation may be effected, either of another tendon from the same individual when there has been extensive injury of the part, or of one taken from a lower animal: in the latter case usually, if not always, the graft is absorbed and its place taken by a new formation. When only one end can be found and separated from the surrounding cicatricial tissue, it may with advantage be united to an adjoining uninjured tendon having the same general anatomical course; as, for example, the flexors or extensors of the hand and fingers or those of the foot and toes. In all cases of tendon-suture much advantage will be derived from the use of the Esmarch bandage during the operation, which will prevent the blood from obscuring the field of operation.

DISPLACEMENT OF TENDONS.—Unassociated with fracture or dislocation, displacements of tendons are of rare occurrence. Consequent upon sudden muscular action or extreme violence the tendon is forced from its normal position, is quickly and spontaneously replaced, or remains luxated until returned by manipulation. The tendons of the peroneal muscles are those most usually affected, especially that of the brevis, which is not very seldom found thrown out of its bed behind the external malleolus and carried forward so as to be readily felt and easily moved upon the malleolus. Slight pressure will return it to its proper place, but it is held there with much difficulty and only imperfectly as a rule. The parts should be immobilized and a retentive dressing kept on until repair of the torn sheath or lateral ligament has taken place, if this can be secured. An aseptic suture or two may assist in retaining it in place. The late Dr. James R. Wood devised and carried into effect an operation for the relief of dislocation of the tendon of the peroneus, viz., tenotomy followed by fixation with plaster of Paris. Dislocation of the tendon of the long head of the biceps flexor cubiti occurs occasionally; White has reported and figured a case.

SECTION III.—AFFECTIONS OF BURSAE.

In connection with some tendons and in close relation with most joints there are to be found bursæ, which are either normally present or acquired. The former are present at the time of birth or soon after; the latter are developed later in life in consequence of muscular action and friction. They may be superficial or deep-seated; many of the latter communicate directly

with neighboring articulations, especially in adults. As the result of injury and of diathetic affections these bursæ are frequently the seat of disease, giving rise to simple excess of fluid; to suppurations; to deposits, tubercular, syphilitic, or malignant; to thickenings; and to fibrous and calcareous degenerations.

BURSITIS.—The inflammations are acute, subacute, and chronic, the last at times succeeding to the second, but generally such from the beginning. When it is one of the superficial pouches that is affected, the prognosis is ordinarily good, though at times, because of neglect of proper treatment, extensive and destructive cellulitis results: when a deep-seated bursa is affected the prognosis is much more grave, since there is danger of the extension of the inflammation to the joint as the result of the affection itself or of the measures adopted for its relief.

Acute bursitis, due ordinarily to injury, at times to over-use, when superficially located, is indicated by pain or at least tenderness, skin-redness of varying intensity, and, particularly, by swelling, coming on rapidly and consequent upon excess of secretion, and, oftentimes, blood in considerable quantity. The peculiar location in relation to a tendon and the limited extent and globular form of the swelling serve to distinguish the disease from an ordinary cellulitis. The associated general symptoms may be of high grade. If suppurative, unless promptly arrested there is strong probability of extension to the connective tissue outside the bursa, with resulting increase in the severity of symptoms local and general. The deep-seated inflammations will often be mistaken for those of the joints near by; and, indeed, in a considerable proportion of cases they actually become articular after a little time, the bursa and the synovial sac either directly communicating or being separated by a thin wall that soon breaks down. Many of the extra-articular inflammations also doubtless originate in bursal disease.

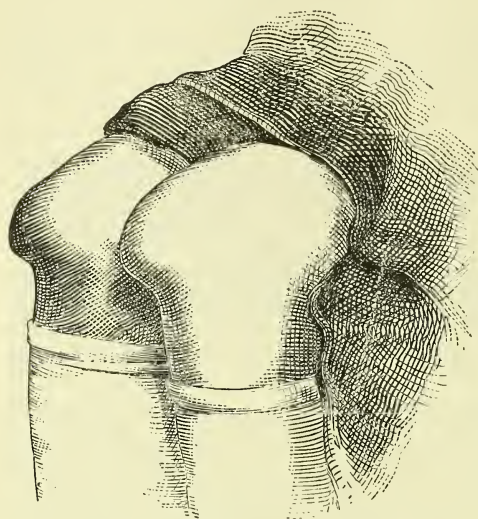
The local treatment is at first by rest, elevation, pressure, and cold applications; later, if the effusion does not rapidly diminish and the inflammatory symptoms do not subside, the sac should be aspirated, or, if pus is present, freely laid open, disinfected by pure carbolic acid, and dressed antiseptically until obliteration of the cavity has been secured. If the patient is rheumatic, gouty, or syphilitic, the ordinary general treatment of the particular diathetic state should be employed.

Chronic bursitis, of much more frequent occurrence than the acute variety, generally gives rise to little or no distress, and is characterized chiefly by swelling, due to sac distention, or to this combined with much thickening of the wall. At times the swelling is solid and of fibrous character, it may be, though rarely, bony. A very common locality is on the front of the knee, the prepatellar bursa being the one usually affected (Fig. 118). It is due to long-continued pressure and irritation, as in those who kneel much, and is known as **housemaid's knee**, as a similar affection of the olecranon bursa is spoken of as *miner's elbow*. The enlargement of the prepatellar bursa is median in position, is globular, usually fluctuates, and, unless it has become acutely inflamed, is painless or nearly so, though some weakness of the knee is often complained of. The subligamentous bursa is sometimes diseased, when the swelling shows itself on the sides of the ligament, the tension of which causes a central depression.

The treatment of the prepatellar enlargement is by aspiration or free incision; the latter, when aseptically done and when the resulting wound is aseptically treated, gives the best result. Instead of a median cut, small openings may be made on the sides and a drainage-tube carried through. When

suppuration has occurred lateral incisions low down are to be preferred to a central one, as they much more certainly secure drainage of the pockets on the

FIG. 118.



Double Housemaid's Knee (original).

sides where the bursa overlaps the inner and outer edges of the patella. If the sac has very thick walls or the mass is solid, it should be dissected out, care being taken in the removal to keep as close as possible to the outer surface of the swelling.

The deeper *subligamentous bursal swelling* will ordinarily be treated by rest, together with pressure or the application of small blisters, and relief may be expected only after considerable time. The likelihood of existing communication with the knee-joint makes aspiration the preferable form of operative treatment.

Occasionally the bursa beneath the *semimembranosus tendon* is diseased, and when it has enlarged

so much as to cause marked swelling, not only, as at first, near the inner border of the knee, but well out to or beyond the median line, the affection may easily be mistaken for an intra-articular one or for an aneurysm. The very general connection of this pouch with the synovial cavity, at least in adults, as a general rule contraindicates any operation other than aspiration.

As the result of abnormal pressure combined with malposition of the articulating surfaces there is frequently observed a bursal tumor over the metatarsophalangeal articulation of the *great toe*, much less frequently over that of the little toe or over one of the other toe-joints. This is known as a "**bunion**" (Fig. 134). It may cause but little inconvenience, but almost always there is some tenderness in the part, and it is quite likely to become acutely inflamed. Then the pain is decided—and it may be excessively severe—the skin is reddened, the fluid in the sac much increased, and walking becomes difficult, and, it may be, impossible. When suppuration occurs the pus may break through the wall and cellulitis be developed, or a joint inflammation be excited and cause more or less destruction of the articulating surfaces. The treatment is that of acute bursitis in general—rest, cold, discutient lotions, tapping, or incision and prompt evacuation of pus. If either the surrounding connective tissue or the underlying joint has become infected, free incision should be made and the wound dressed antiseptically. Should the bone have become diseased, it must be removed by the sharp spoon or the gouge forceps, and the previous malposition of the toe corrected during the period of healing.

CHAPTER V.

ORTHOPEDIC SURGERY.

ORTHOPEDIC SURGERY has to do, properly, with the treatment of *deformities and contractions*, especially by some form or other of mechanical appliance, though of late its field has been somewhat extended so as to include the consideration of many deformity-producing joint affections.

TORTICOLLIS, or WRY-NECK, is a contracted state of one or more of the muscles of the neck, producing an abnormal position of the head. As ordinarily observed it affects, either wholly or chiefly, the sterno-cleido-mastoid muscle (Fig. 119), though the deep muscles are at times at fault, and in long-standing cases they are apt to be in greater or less measure involved. It is occasionally

acute, and is then commonly due to either cold or trauma. But it is more commonly chronic, and is then spastic in character and dependent upon nerve-irritation. It has been produced by an habitual malposition of the head, assumed because of existing ocular defect. It is noticed commonly in young children: though rarely, it may be congenital and due to vertebral deformity or to injuries received at time of birth. If it first appears in adult life, as it does occasionally, though fortunately not often, instead of being spastic it is intermittent, spasmodic, and generally affects one or more of the muscles innervated by the spinal accessory nerve. When acute it generally passes away under the influence of rest, heat, and time, or it may become chronic and permanent. The spasmodic variety may disappear without treatment or after the employment of baths, friction, and massage, electricity, tonics, quinine (for it may be of malarial origin), change of locality, etc., or it may remain until stretching, section, or removal of a portion of the spinal accessory nerve be done; and even these operations may leave the patient little or no better than before.

The **diagnosis** of the commonly observed spastic contraction of the sterno-cleido-mastoid muscle is easy: the head is turned to the opposite side, the chin is extended, the ear of the affected side is drawn downward toward the shoulder, and the muscle is in strong relief and abnormally firm. At times only one of the divisions of the muscle, and that more commonly the sternal, is markedly contracted. When the disease has been of long duration there is often decided atrophy of the corresponding side of the face. The posterior rotator muscles of the neck are probably involved, together with the sterno-mastoid. Pain is not usually present. Rectification of the malposition can often be effected, at

FIG. 119.



Torticollis (original).

least to a considerable extent, voluntarily or by manual pressure, but at once recurs when the pressure is removed. When the deeper muscles are diseased there may be a question as to the existence of caries of the cervical spine, but the history of the case, the absence of bilateral rigidity, and the character of the deformity will generally suffice to indicate the nature of the trouble.

Having no tendency to get well of itself, the *spastic form* should always be **treated** either mechanically or by operation, followed by the application of proper retentive apparatus. Collars and braces of various kinds have been devised with the intention of holding the head in the improved position secured by forcible manipulation, and the plaster-of-Paris bandage over head, neck, and shoulders has been used for the same purpose. Often in the milder cases relief of the deformity may, in time, be secured by such appliances, but whenever the muscular contraction is well marked the tendon and the adjacent fascial bands should be cut, either subcutaneously or through an open wound. Until recently the former method was almost uniformly employed, being much safer and leaving but a very slight scar; but, aseptically made, the open wound is attended with little or no risk, and has the advantage of permitting a more complete division of the contracted tissues. The subcutaneous method will, however, often be preferred. The head being so held as to render the tendon tense, a small incision is made low down over its internal border; through this a blunt-pointed tenotome is carried to and along the under surface of the sternal portion, its cutting edge turned forward, and section made, after which, in the same manner, the clavicular portion may be divided if necessary. At times the sternal tendon can be cut upon the bone, thus avoiding the danger of wounding the anterior jugular vein as it passes behind the muscle a short distance above the sterno-clavicular articulation—an accident, however, of little moment, as the hemorrhage can be easily controlled by pressure and the clot will soon be absorbed. The internal jugular vein has been wounded, the knife having been carried too far back in the first stage of the operation.

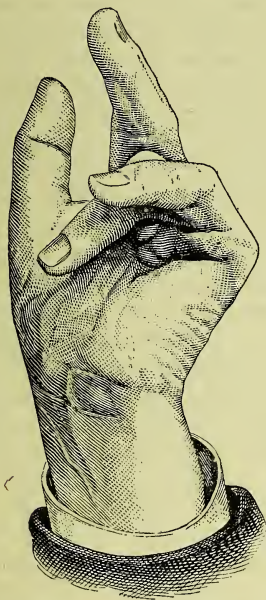
As has been stated, for the relief of *spasmodic wry-neck*, affecting the sterno-cleido-mastoid muscle, the *spinal accessory nerve* may be stretched, cut, or in part removed, the latter being much the most promising procedure. To expose the nerve an incision may be made along the posterior edge of the sterno-cleido-mastoid muscle at its middle or along the anterior edge, beginning at the mastoid process and carried downward for about three inches: the muscle being drawn aside, the nerve can be readily lifted and a piece of it cut away. Exsection of one or more of the upper cervical nerves when the posterior muscles are affected necessitates careful dissection and somewhat extensive division of the trapezius and complexus muscles, and will not often be performed.

CONTRACTURES.—As has already been stated, there are at times observed in adults, as late phenomena of hemiplegic paralysis, contractures of the muscles of the arm, forearm, and hand, especially of the flexors: such contractures increase in intensity in proportion as the parts to which the muscles are supplied are farther removed from the trunk. As commonly seen, the arm is adducted, firmly held against the side (though occasionally it is abducted), the forearm is flexed upon the arm, the hand upon the forearm, and the fingers upon the palm; these flexions cannot be entirely overcome by either passive or active movements in extension. The deformity produced is proportionate to the degree of contracture, and ordinarily is not relieved by any treatment. Traumatic contractures due to wounds, not seldom to burns, and those consequent upon extensive cellulitis with loss of tissue and the formation of strong

cicatricial adhesions, are so variable in locality, extent, and force that each case must be treated according to its special indications, mechanically or operatively, by the use of apparatus or by stretching, rupturing, dividing, or by the plastic insertion of healthy tissue taken from a near or a remote part of the body or from a lower animal. At times the disability consequent upon the irremediable deformity is so great that amputation is done. For the treatment of contractures by lengthening of the tendon, see p. 328 (Fig. 113).

CONTRACTION OF THE PALMAR FASCIA (*Dupuytren's contraction*) (Figs. 120 and 121), producing permanent flexion of a finger or fingers, is at times

FIG. 120.



Dupuytren's Contraction of the Palmar Fascia (Keen).

FIG. 121.



The Same Hand after Operation (Keen).

met with, generally in individuals beyond the middle period of life, much more frequently in men than in women. It affects indifferently either hand, sometimes both. The ring or the little finger or both are most frequently flexed; next the middle finger; the thumb and the index more rarely. The degree of flexion varies with the case and the length of time that the disease has existed.

It is not the flexor tendons that are contracted, as was formerly believed to be the case, but the palmar fascia and its digital prolongations, together with the fibrous bundles uniting the fascia and the overlying skin, which latter is involved only late and secondarily if at all. Beginning usually as a small hard nodule at or near the line of the metacarpo-phalangeal articulation, the disease extends more or less slowly both downward and upward, with corresponding drawing down of the affected finger or fingers, until in very severe cases the finger-tip is strongly and steadily held against the palm. Its occurrence has

been attributed to the action of various causes,—slight traumatisms frequently repeated, the rheumatic or gouty diathesis, reflex nervous irritation, etc.; but which of these is its real cause, or whether it depends upon any single cause, has not been determined. It certainly seems to be most frequent in those who are rheumatic or gouty. A recently-reported cure by hypnotic suggestion, as far as it goes, gives support to the nervous theory.

The **diagnosis** is easily made: the thickened elevated band in the palm extending to the sides of the finger, the marked flexion resisting strong efforts at extension, the absence of pain, the slow development of the condition, the age of the individual, the non-existence of cerebral or spinal disease, or of injury of the extremity followed by loss of substance and resulting scar-contraction,—all taken together render it impossible to mistake the nature of the affection.

Treatment.—Left to itself, the palmar contraction always gets worse, and it can be relieved only by operation. Such operation may be either subcutaneous or open. If the former, the contracted bands are divided by a tenotome at a sufficient number of points, and the attachments to the skin separated until full extension of the fingers can be secured, after which a retaining splint and bandage are applied and worn until healing has taken place, and for a considerable time longer during at least a part of each twenty-four hours. The fingers for a few days should be slightly flexed, and later completely extended. In the open operation the skin may be divided by a linear wound or reflected in a V-shaped flap, base downward, and the contracted tissue dissected out, or the bands divided sufficiently freely by cross cuts at different levels—an operation which of late years has been frequently done with entire success.

CLUB-HAND (Fig. 122) may occur congenitally as the result of defective osseous development, or later because of wounds attended with much loss of

FIG. 122.



Double Club Hand (original).

substance in the soft parts or the bones of the forearm or carpus, or of paralytic contractions. There is a deviation, lateral, anterior, or posterior (very rarely the latter), similar to that in the lower extremity constituting club-foot, and hence known as club-hand. Generally the hand is drawn over in flexion and toward the radial side.

It is often present at birth, or has followed extensive resection of the lower part of the radius or ulna or of the carpus. Little or no relief can usually be afforded, though early and persistent manipulation, with the use of a retentive dressing, plaster or instrumental, has occasionally been followed by decided improvement in the position and usefulness of the hand. Always after bone-removal, especially of the lower end of the radius, care must be taken for many months to prevent the deflection of the hand, otherwise likely to occur, by passive and active movements, and, if necessary, by the employment of a suitable apparatus. Tenotomy ordinarily has done little good, and at times has done harm.

WEBBED FINGERS (SYNDACTYLISM) is a congenital affection. It may affect two or more fingers on one or both hands, the union extending to any point, even to the tips. There may be a wide web of skin with but little connective tissue within, or a narrow and thick one, or the phalanges of the two fingers may be in close apposition. Frequently the deformity is a family peculiarity, running back through three, four, or more generations. If only two fingers are united, they are usually the ring and middle ones. The strength and use-

fulness of the hand are often but little impaired. Simple division of the web rarely gives other than temporary relief, the web re-forming from the bottom as the wound heals. To prevent such re-formation a flap of skin may be fixed in the angle between the separated fingers (see Fig. 123), or a small hole may at first be made at the level of the edge of the normal web, in which a thread or a button may be placed and retained until the edges of the cut have healed, after which the remainder of the web may be cut through.

FIG. 123.

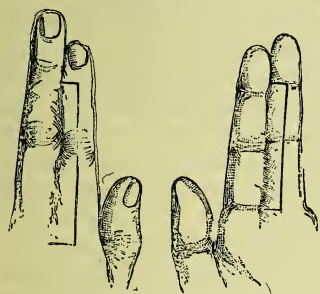


Agnew's Operation for Webbed Fingers.

The most satisfactory operation is Didot's, in which a flap the length of the finger and half its width, with the added width of the web, is taken from the dorsal surface of one finger and the palmar surface of the other (thus splitting the web and separating the fingers), and each carefully applied over the denuded portion of the finger to which it is attached, securing a normal skin covering of the surfaces that are to be in apposition (Figs. 124, 125).

FIG. 124.

FIG. 125.



Didot's Operation for Webbed Fingers (Walter Pye).



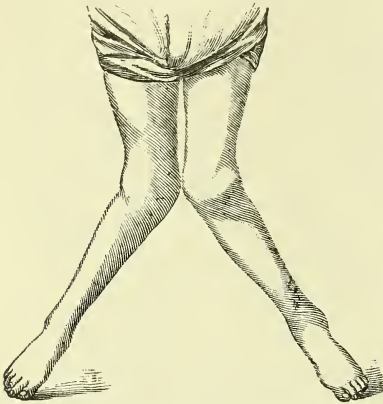
Transverse Section, showing flaps before and after suture.

are generally symmetrical, and often present on both hands and feet. Usually there is but a single digit in excess, commonly on the side of the little finger or little toe; though not rarely the thumb, much less often the great toe, is double. The development may be complete, even to an extra supporting metacarpal or metatarsal

bone, or it may be more or less imperfect, so that the supernumerary digit is scarcely more than a rudimentary nodule connected with the side of a phalanx. When perfect it is most often attached at a greater or less angle to the broadened end of the metacarpal or metatarsal bone of the normal finger or toe, though at times the normal and extra digit are very closely apposed, or even fused, and held in a common envelope of skin. At times the connection with the hand or foot is by a fibrous band of varying length and firmness. It may be amputated at any time, but if not closely fused with the adjoining digit it is best to remove it very soon after birth; and even if so fused, it should be taken away while the child is still quite young, to lessen the resulting deformity. If there is a completely formed hand or foot, with an extra metacarpal or metatarsal bone and corresponding digit, no operation need, or indeed should, be done.

GENU VALGUM, OR KNOCK-KNEE (Fig. 126).—This is the result of overgrowth of the internal condyle and curving inward of the shaft of the femur

FIG. 126.



Genu Valgum, or Knock-Knee (Bradford and Lovett).

in its lower part, with associated relaxation and elongation of the internal lateral ligaments of the knee-joint. These changes produce an abnormal inclination of the interarticular line, more or less close approximation of the knees, and more or less wide separation of the feet, the individual in standing being unable to bring the heels together.

It usually manifests itself in early childhood, soon after the child begins to walk, but may not do so until about the period of puberty, or even, though rarely, much later in life. In the former case it is a rachitic manifestation; in the latter, it is consequent upon an occupation requiring long-continued standing by a person of feeble muscular and ligamentous development. Often there is associated flat-foot, which, indeed, at times may be the primary and causative lesion. It may affect

one or both knees, may be so slight as to escape detection except upon very careful examination, or so severe as to cross the knees, separate the feet very widely, and render locomotion difficult and the gait wabbling. In children other evidence of the existence of rickets will commonly be found.

The **diagnosis** is made on sight, except in the mildest cases.

Left to itself, when not severe it often spontaneously improves as the rachitic state passes away and the general strength increases. This favorable termination is common in the static knock-knee of adolescents.

The earlier, however, that **treatment**, general and local, is begun, the speedier will be the recovery and the less the resulting deformity. The ordinary medicinal and hygienic treatment of weak and rachitic subjects is the appropriate one for young children. The local treatment is mechanical, supplemented by baths, frictions, massage, electricity, and preceded, in the severer cases, by osteotomy.

If the rickets is still active and the bones are soft and yielding, standing and walking should be forbidden, the limb should be straightened as much as possible by manipulation, and maintenance of the correct position should be secured by an outside splint and bandage. Later, when the bones have become firmer, great benefit often follows the use of such a splint with a counter-pressing pad on the inside, the resulting change in the relative positions of the articular surfaces of the femur and tibia permitting the increased growth of the external femoral condyle with restriction of that of the internal. Plaster of Paris is an excellent material for this splint, or the limb may be completely enveloped in it.

Immobilization with the leg flexed at a right angle with the thigh is, by many, preferred to that in the straight position, as the deformity is much lessened by the flexion. Forcible rectification followed by immobilization has often been followed by great improvement, there being produced in the rapid straightening an epiphyseal separation of greater or less extent or a laceration of the external lateral ligament. But if sufficient force to produce such condition is required, it is better instrumentally to break the thigh at a determined level or to divide the bone with saw or chisel, especially as severe injury to the soft

parts and the joint structures has at times been produced by the former method. Braces of various kinds have been devised, all intended to correct the deformity and allow the patient to go about, and many of them are of much service in very young children.

If the knock-knee is great and the bones are firm, no material change for the better can be effected without operation, either fracture (osteoclasis) or section (osteotomy), of which the latter is to be preferred, fracture requiring the use of a special apparatus, and not always being produced at the desired place. Section may be so done as to separate the internal condyle or divide the lower portion of the femur, which latter is the operation ordinarily performed. A small longitudinal incision being made down to the bone, half an inch or a little more above the adductor tubercle, the osteotome is introduced, turned at a right angle, and by successive blows of the hammer driven toward the outer side, being so moved upward and downward as to secure division of the entire thickness of the bone for three-quarters or four-fifths of its transverse diameter, the uncut portion being readily broken by moderate force. The limb is then to be straightened, an antiseptic pad applied, a layer of cotton put on, and immobilization made by plaster of Paris. Little or no reaction ordinarily follows: in about a month the dressing may be taken off, and after two or three weeks' additional rest the patient is allowed to walk. Though the operation is not altogether devoid of danger, since there may be serious hemorrhage from a divided popliteal or anastomotica magna artery, or from the bone itself, or a resulting aneurysm or gangrene, causing death or necessitating amputation, or damage inflicted upon the external popliteal nerve, yet the likelihood of these accidents is very slight, and may be practically disregarded in deciding upon the advisability of making the section. (See Osteotomy.)

GENU VARUM, or BOW-LEGS (Fig. 127), the opposite of genu valgum, is a deformity usually affecting both limbs, in which the knees are more or less widely separated, the joint surfaces are in such relation to each other that the angle between them points outward, and the chief pressure is between the internal condyles. Except in a very few cases there is outward curvature of the femur and tibia, or of the tibia alone, with at times an anterior bend of the latter bone. The curves of the two legs together may form an almost complete circle. A line drawn from the center of the femoral head to the ankle is internal to the knee. The disease begins in early childhood and is of rhachitic origin, and the deformity is the direct result of the weight of the body and muscular action. Inspection at once reveals its existence, which is further indicated by the turning in of the feet and the rolling walk. In elderly persons suffering from osteitis deformans there may be a bow-legged condition which is a part of the general bone disease, and is irremediable.

Treatment.—Spontaneous correction sometimes occurs, much more frequently than in genu valgum; but if the case is at all severe and the child so young that the bones have not become firmly set in the abnormal curves, mechanical treatment should be employed to bring the limbs in toward the median line. This may be by plaster or braces, according to circumstances. In older patients the bones are too strong to yield to any such pressure, and correction of the deformity can be made only after fracture or section. Though

FIG. 127.

Genu Varum, or Bow-Legs
(Bradford and Lovett)

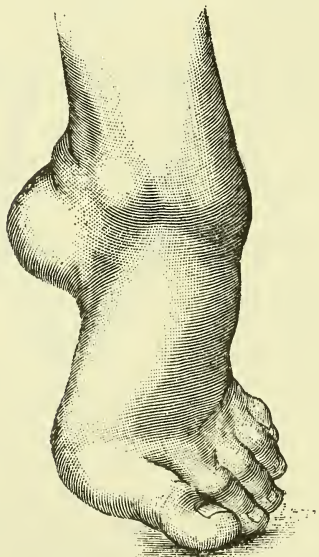
osteoclasia by the aid of one or other of the instruments now employed gives better results than in cases of genu valgum, yet osteotomy is the operation that is generally done, linear division being effected at such levels as the condition of the individual case may indicate. The method of operating and the after-treatment are the same as in knock-knee.

Turning in or turning out of the knee consequent upon paralysis or vicious union after fracture requires no special consideration. Each case must be treated according to its character, medically, mechanically, or operatively.

ANTERO-POSTERIOR CURVATURE OF THE LEGS is another of the deformities due to rickets which in its aggravated form can be relieved only by operation. When slight and detected early, it may be expected to disappear, either without treatment or more probably under rest and appropriate fixation dressing; but in neglected cases, in some of which there is excessive bowing, linear or often cuneiform osteotomy must be done on one or both bones according to circumstances. In the performance of the latter the summit of the curve in the tibia is freely exposed by a longitudinal incision of sufficient length. By a saw or chisel a wedge, with its base anterior, is cut out of the tibia, after which, if necessary to the straightening of the leg, the fibula is broken or instrumentally divided. Tenotomy of the tendo Achillis also is generally needed. Proper adjustment having been made, the limb is immobilized and quietude maintained until repair and consolidation are completed. The operation and dressing must be done aseptically, that suppuration may not take place, which will always materially lengthen the period of treatment. There is a risk, but not a great one, of wounding the anterior tibial vessels or nerve.

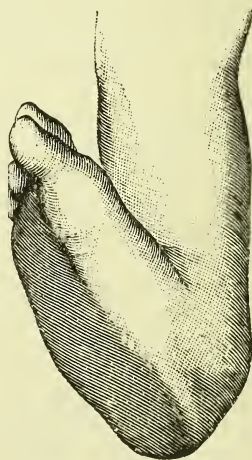
CLUB-FOOT, or TALIPES, is a non-traumatic deviation of the foot in the direction of one or other of the four lines of movement—extension (*T. equinus*, Fig. 128), flexion (*T. calcaneus*, Fig. 129), adduction (*T. varus*), and abduc-

FIG. 128.



Talipes Equinus (Albert).

FIG. 129.



Talipes Calcaneus (Albert).

tion (*T. valgus*),—or of two of these combined, as in equino-varus (Fig. 130). It is due either to under- or over-action of muscles or to abnormal position,

shape, or relations of one or more parts of the skeleton of the foot. It may be either congenital or acquired, in the latter case being generally developed in early childhood and the result of infantile paralysis (acute anterior poliomyelitis).

In the congenital variety the displacement is almost always one of adduction, with commonly some elevation of the heel (*TALIPES EQUINO-VARUS*, Fig. 130). Generally affecting both feet, it may be confined to one, the right oftener than the left. The inner border is raised, the sole turned toward the median line of the body, the heel more or less lifted, the distal part of the foot flexed upon the proximal part at the mid-tarsal articulation. The degree of deformity varies from that which is but little in excess of the natural inclination of the foot of the new-born infant up to so great rotation that the weight in the erect posture is borne upon the upper and outer part of the dorsum. At the time of birth and for some months afterward the deformity can usually be easily corrected by manipulation, but later, if left to itself, it becomes in greater or less measure fixed, in consequence of muscular contraction and developmental changes in the shape of the bones.

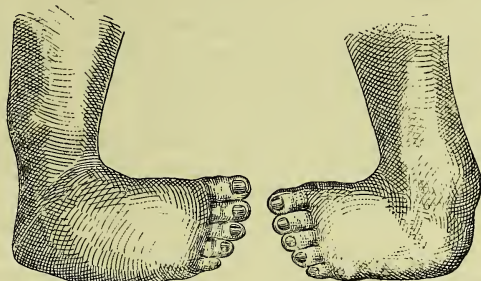


FIG. 130.

Double Equino-varus (original).

As to its **cause**, there has been much question. It has been attributed to uterine pressure, to intra-uterine disease of the cerebro-spinal axis with resulting paralysis and arrests of development (it is not seldom associated with malformations of the head, the face, the spine, the abdominal wall, or the pelvis), and to persistence of the earlier foetal position of the foot, the later normal rotation of the leg and foot, or at least of the latter, not having taken place—an explanation that seems, at present, the most likely to be correct. In a considerable number of cases it is a family peculiarity, either in the ascending line or affecting several children of the same parents.

The **diagnosis** is easy, and the **prognosis** good if proper treatment is promptly adopted and steadily maintained for a sufficient length of time, though even under the most favorable circumstances the ultimate development of the foot is not what it would have been had the deformity not existed.

The **treatment** must be either manipulative or mechanical, or both. In those cases—and they are the majority—in which at birth and soon afterward the foot can readily be brought into proper position by hand-pressure, such pressure, could it be steadily maintained, would in time relieve the deformity. As this cannot be done, some substitute for it must be found, and that is best which most nearly approaches it in evenness and gentleness of pressure. Simple bandaging or the application of adhesive straps has been used, and, at times, with success, but immobilization of the foot and leg by plaster of Paris or gutta-percha is very much better, the parts being protected by cotton and the dressing carried sufficiently high up to prevent its ready displacement. Frequent removals and reapplications of the plaster will be required. Very rarely in these young subjects is there such tendon contraction as to necessitate section. The earlier the deformity is corrected and the foot held in right position the better. If the case has been neglected and nothing done until the child has begun to stand and walk, the malposition may

still be corrected by manipulation and overcome by immobilization, but with much more difficulty. Decided retraction of the heel may often in this way be relieved, but considerable time will be required—time which may be saved by tenotomy. The tenotome is introduced by the side of the tendo Achillis (rendered as tense as possible by flexion of the foot), carried underneath it, its cutting edge turned against it, and division made by pressure and a slight sawing motion. There are but two dangers in this operation, that of wounding the posterior tibial artery, and that of freely dividing the skin, neither of which is likely to occur if care is taken. If either accident does happen, it is usually a matter of no great importance. Pressure will stop the flow of blood, and under antiseptic treatment the open wound will quickly close without inflammation. Elastic traction has been employed with much benefit.

Upon far the larger number of these patients club-foot shoes are applied. They should be either solid or jointed opposite the middle tarsal articulation to permit of any required lateral movement of the parts in front. The side-pieces should be carried nearly up to the knee. If properly made, adjusted, and watched, if it overcomes the deformity and maintains the correction, such mechanical appliance is of great service. But as very often used it is of little or no benefit, frequently a positive injury, since it is put on by an instrument-maker or dealer uninformed in anatomy or pathology, and makes uneven pressure, produces callosities and ulceration, fails to hold the foot in proper position, frequently breaks and gets out of order, thus necessitating expense that can be ill afforded, and is often worn long after it should have been thrown away and a new one applied. Much better results will be secured by the average practitioner, and especially among the poor, by plaster-of-Paris immobilization than by the use of a club-foot apparatus.

Before a proper mechanical appliance can be put on, forcible correction under anesthesia may have to be made, together with tenotomy of the tendo Achillis, of the tibial tendons, anterior or posterior or both, and of the plantar fascia. In the aggravated long-standing cases in which there has taken place marked change in the shape of the bones, in the length and position of the ligaments, and in the connective tissues of the foot, rectification cannot be effected except after operation upon the bones or soft parts or both. A wedge-shaped piece may be taken out of the tarsus (cuneiform osteotomy), or the cuboid, the scaphoid, or the astragalus may be removed, or a free transverse incision may be made through all the soft parts of the sole of the foot, which has been done many times of late and with great benefit (A. M. Phelps). Removal of the astragalus gives an excellent result, preferable to that secured by osteotomy. Always after operation a proper retentive apparatus must be applied and its use continued for a long time.

NON-CONGENITAL TALIPES, as has been stated, is almost always of paralytic origin. It may affect one foot or both, and when double, unlike what is true of the congenital variety, the deviation may be in opposite directions. It may be noticed as soon as the child begins to walk, or may appear later, according to the time at which the spinal disease occurs. There is usually decided elevation of the heel, with less lateral deviation than in the congenital cases, or, it may be, none at all, and passive movements at the ankle and middle tarsal joints are readily made until spastic contractures of the muscles limit or prevent them. This freedom of movement, together with the coldness of the parts and marked atrophy of the leg and foot, and at times the associated paralytic or paretic state of the upper extremity, serves to differentiate the affection from the congenital form. The prognosis is less favorable than in the latter, because of the causative muscular paralysis.

The **treatment** is much the same: rectification of the malposition by manipulation, gentle, forcible, or after tenotomy according to circumstances; and maintenance of the proper position by immobilization or by apparatus. The latter has the advantage of permitting the employment of massage, the douche, electricity, and supplementary elastic traction; all of which should be combined with the operative and mechanical treatment.

TALIPES VALGUS, generally non-congenital, is characterized by flatness of the foot, abduction of its anterior part and more or less elevation of its outer border, from yielding of the arch. It occurs ordinarily in feebly-developed persons, especially children, being the result of weight coming upon a foot unable to sustain it, and may be associated with rickets, spinal curvature, knock-knee, or badly united fracture. In the aggravated cases decided displacement of the tarsal bones occurs, especially of the astragalus and the scaphoid, together with changes in the ligaments uniting the os calcis, the astragalus, and the scaphoid. In children pain is commonly absent, but in adults it is often complained of after long standing or walking, and upon pressure there is generally found to be tenderness in front of the inner malleolus, over the junction of the astragalus and scaphoid, and over the proximal ends of the inner and outer metatarsals. The **treatment** is both general and local, consisting of tonics, gymnastics, frictions, massage, and the douche, and especially the use of a supporting steel plate as a substitute for the normal arch. Under such treatment the prognosis is good. When there is present simply a weakness of the ankle, support should be given either by a leather or steel anklet or a brace shoe.

TALIPES CALCANEUS (Fig. 129) is not seldom seen as the result of infantile paralysis, and occasionally at the time of birth. It consists of a deviation in the direction of flexion, the patient walking upon the heel with the anterior part of the foot raised, with or without some associated abduction. Relief may often be afforded by manipulation alone, and generally by fixation by bandages, a shoe, or a shoe and brace. Tenotomy will seldom be required. In a few very severe cases a portion of the tendo Achillis has been removed and its shortening thus secured.

PES CAVUS, or **HOLLOW FOOT**.—As the result of contraction of the peroneus longus or of the deep muscles of the foot, or of paralysis of the calf muscles, marked exaggeration of the arch, with approximation of the heel and the heads of the metatarsals, is occasionally produced. This is known as *pes cavus* (Fig. 131)—a condition which may be somewhat relieved by a steel sole-plate with counter-pressure over the dorsal prominence. In the comparatively few cases in which the deformity is the result of disease or injury with subsequent contraction, cicatricial or otherwise, the deviation varies with the cause, and may require for its relief the use of some mechanical

FIG. 131.



Pes Cavus (Albert).

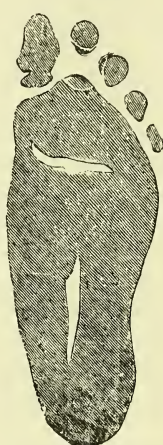
appliance or operative treatment—tenotomy, section of the plantar fascia, free incision, resection, or amputation.

PES PLANUS, or **FLAT-FOOT** is due to an obliteration of the normal arch of the foot, and is therefore the opposite of *pes cavus*. The **diagnosis** of these two conditions is generally easily made, not only by observing the arch of the foot, but also by wetting the foot-sole with a colored solution and making the patient step once squarely on a piece of white paper.

FIG. 132.

Print of a Normal
Foot-sole.

FIG. 133.

Print of a Flat
Foot-sole.
(Albert.)

foot-sole (Fig. 132) the broad impression of the ball of the heel and that of the balls of the toes is connected by a moderately wide isthmus along the *outer* border of the foot. In *pes cavus* this isthmus disappears, and in *pes planus* (Fig. 133) it is greatly broader than it ought to be. The condition is often associated with *talipes valgus* and lateral curvature of the spine.

The **cause** is usually general weakness, combined, as a rule, with long-continued standing, as in mill-girls. Walking, unless very excessive, rarely produces it, as this tends to strengthen the foot. The chief **symptom** is pain, which is produced and is aggravated by standing, and often makes this posture impossible for any length of time. The best **treatment** is a general constitutional tonic treatment, looking to greater vigor of frame, less by drugs than by hy-

gienic means. Locally, a steel artificial arch under the sole, with an internal lateral offshoot, will generally give much relief, and may even cure.

HYSTERICAL CLUB-FOOT is at times observed, and the possibility of its existence should be kept in mind when the age, sex, and neurotic temperament of the patient are such as to favor its occurrence.

A moderate degree of equinus, the **POINTED TOE**, is frequently met with just after recovery from a fracture of the lower extremity, and care should be exercised to prevent its development by keeping the foot at a right angle with the leg during the period of treatment, although the deviation ordinarily soon disappears after the patient begins to walk about.

HALLUX VARUS, or **VALGUS**.—Displacement of the great toe may be either away from or toward the other toes (*H. varus* or *H. valgus* (Fig. 134), respectively), most frequently the latter. It is present to a slight degree in the majority of adults, and has been observed at times even in young children; but troublesome *hallux valgus* is met with, as a rule, only in persons beyond middle age, and in advanced life is often associated with chronic rheumatoid arthritis. Because of the wearing of a too narrow, too short, too pointed, or badly-fitting shoe, or not seldom of a similarly faulty stocking, the great toe is crowded over upon the others and inclined at a more or less obtuse angle with the inner border of the foot. As a result, the normal relations of the bones of the metatarso-phalangeal joint are disturbed, and the pressure of the shoe causes bunion and periosteal irritation, and may even give rise

FIG. 134.

Hallux Valgus and
Bunion (Bradford
and Lovett).

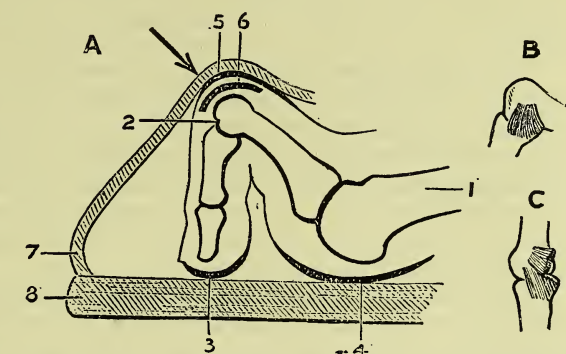
to destructive inflammation of the soft parts and bone. Pain and disturbed locomotion are common in the more severe cases.

The **treatment** is either mechanical or operative. In the first case an apparatus is applied to draw the toe to its proper place and hold it there, and at the same time protect the bunion from pressure; in the second the articular extremities of one or both bones are removed with the saw or the cutting forceps—*i. e.* complete exsection of the joint. Another plan of treatment which often gives good results is division of the metatarsal bone, often the only satisfactory method of treatment. A properly-shaped and well-fitting shoe should always be worn afterward. The use of such a shoe from childhood on will prevent the production of the deformity.

HAMMER-TOE.—There is observed at times a permanent angular flexion of one or more of the toes, especially the little and second, at the first phalangeal articulation, the third phalanx being either in line with the second or in extension or flexion on it. The first phalanx is usually extended. Thickening over the phalangeal joint is generally present, bunion may be developed, and partial luxation often occurs (Fig. 135). This is known as hammer-toe, and is the result of contraction of the plantar fibres of the lateral ligaments of the joint (Shattuck). Beginning usually in later childhood, and oftenest in boys, the deformity is the cause of much inconvenience, and at times of actual suffering.

Relief is afforded only by operation. The lateral ligaments have been divided, and subcutaneous and open division of the soft parts on the under surface of the first phalanx done, but, as a rule, without satisfactory result. Either the toe should be removed or, what is better, the joint excised. A similar disorder exists in the hand, known as *hammer-finger*.

FIG. 135.



Hammer-Toe : A, a diagram of the position of lines in hammer-toe : 1, metatarsal line ; 2, head of the first phalanx ; slight groove corresponding to position of dorsal border of second phalanx ; 3, 4, 5, callosities due to boot pressure ; 6, bursa over contracted joint ; 7, 8, shoe (the arrow indicates the direction in which the pressure of the upper leather tends to force downward the head of the metatarsal line toward the sole) ; B, dissection of first interphalangeal joint in hammer-toe ; C, the same preparation after section of plantar fibres of lateral ligaments (Anderson).

CONGENITAL DEFORMITIES BY EXCESS AND DEFICIENCY.

In both the upper and the lower extremities there are occasionally observed errors of development producing abnormal enlargement of a part or the whole of a limb, or, more frequently, deficiency, due either to arrested growth or absence of an anatomical segment, or both combined, the result being a malformation affecting the functional value of the extremity in any degree from the slightest to the most extreme. The hypertrophies other than of a finger or toe are not amenable to treatment. The use, if necessary, of a raised shoe may overcome the asymmetry in length of the lower extremities. The finger or toe of excessive size, in which generally not only the bones but also the soft parts, especially the blood-vessels and lymphatics, are affected, should be removed at as early a time as practicable. Deformities from non-development, interest-

ing as they may be anatomically and teratologically, are surgically of interest only when enough of the limb has been developed to permit of the application of some form of prosthetic apparatus, or when one of the two bones of the forearm or leg is either entirely wanting or so defective as to permit of deviation of the hand or foot from muscular action, in which case a supporting and restraining apparatus is of much value.

CHAPTER VI.

SURGERY OF THE NERVES.

SECTION I.—GENERAL CONSIDERATIONS.

THE larger nerves, like the blood-vessels, as a rule, lie in the protected parts of the body, so that happily they often escape injury. Thus in the neck the nerves lie deeply, protected in front by the collar-bone and laterally by the muscles of the neck. In the arm they lie in the armpit, on the inner side of the upper arm, and on the flexor aspect of the forearm. In the trunk and the pelvis they lie on the posterior wall of these cavities, and in the leg, chiefly on the posterior aspect of the limb, while those on the anterior aspect are, as a rule, very deeply situated.

If we examine a nerve of any size, we find that it has on its exterior a sheath, called the perineurium, between which and the nerve proper is a narrow lymph-space. The perineurium sends offshoots into the interior of the nerve, making partitions which enclose similar bundles of primitive nerve-tubules, the partitions themselves constituting the endoneurium. Nerves are also supplied with blood-vessels and with *nervi nervorum*.

It will be seen, therefore, that, however small, each nerve has within it all the elements necessary for inflammatory changes, and in the connective tissue of the perineurium and endoneurium all the possibilities for such new growths as may be derived from this tissue. Waller has called attention to the degenerative changes which follow section of a nerve, and which constitute the "Wallerian degeneration." It follows the course of the nerve-current. Hence, if a sensory nerve be cut, the Wallerian degeneration will start at the point of section and travel toward the spine; while if a motor nerve be cut, the degeneration will extend from the point of section toward the periphery. This process begins within a day or two after the section and becomes complete in two or three weeks. It consists in the destruction of the myeline, and eventually of the axis-cylinder, with multiplication of the nuclei of the sheath. In addition to this there is more or less atrophy with other degenerative changes, which extend not only toward the spinal cord, but even into it: in some cases, for instance after amputation, such changes have been traced all the way to the brain. The muscles supplied by such a divided motor nerve soon show the "reaction of degeneration." By this term is meant a peculiar change in the response of the muscles to the galvanic current. In the normal condition it will be found that the kathodic closure contraction (KCC)—that is, the contraction which follows closure of the electrical circuit by the application of the negative electrode (kathode)—is greater than the anodic closure contraction (ACC)—that is, the contraction following the similar application of the positive electrode

(anode)—a condition which is expressed by the formula $KCC > ACC$. If the muscle have its motor nerve destroyed, the ACC quickly increases until $KCC = ACC$, and finally $KCC < ACC$.

After division of a nerve, even in cases in which the two ends have not been brought into apposition, reunion with true regeneration of the nerve-structure will often take place, the axis-cylinder having been redeveloped and the myeline also, in varying amounts. If, however, the nerve-ends are united, this process is not only hastened, but is also much more apt to be permanent than where no such union has been effected.

SECTION II.—NEURITIS, OR INFLAMMATION OF A NERVE.

Causes.—A neuritis may be idiopathic; that is, arising from no perceptible cause. By far the commonest cause is exposure to wet or cold. Gout, rheumatism, syphilis, typhoid fever, diphtheria, and the exanthemata may also give to rise such an inflammation. Of course it follows wounds and injuries of nerves. Occasionally, but rarely, it assumes the dangerous form known as multiple neuritis, or, better, diffused neuritis, which may even cause death.

Neuritis may be either acute or chronic. In *acute neuritis* there will be a marked increase of the connective-tissue elements of the nerve, with œdema of the sheath from the exudation. The nerve-tubules become softened as a result of granular and fatty changes, as well as from the inflammatory exudate, and in some cases even pus may be present. Occasionally there will be hemorrhage into the nerve substance.

In *chronic neuritis* there is apt to be sclerosis from the development of the connective tissue of the endoneurium with pressure on the tubules, which, as a rule, results in their atrophy. In such a nerve the fibrous tissue may be so developed as to make the nerve almost as tough as a tendon. In spite, however, of such complete changes, there may almost always be seen single nerve-tubules, which are perfectly normal, associated with others in every stage of degeneration. It is very important to observe that a neuritis may extend in both directions along the trunk of the nerve. Such a progressive neuritis is called either an "ascending" or a "descending neuritis," as the case may be. Its commonest pathway, however, is upward toward the spine, and hence if, for example, the ulnar nerve be the seat of the neuritis, the inflammation may creep upward till it reaches the brachial plexus and there involves another branch of the plexus by continuity of structure. On the other hand, it is a remarkable fact that a nerve may lie in the midst of inflamed tissues, and even be surrounded by pus for a long time, without any inflammatory change extending to the nerve itself.

Symptoms.—The first symptom of neuritis, as a rule, is an aching pain, which follows the course of the affected nerve, and often prevents sleep. This pain is apt to be remittent, is markedly worse at night, and is increased by motion of the limb or by pressure or friction over the nerve. Not uncommonly it will extend, it is thought by a reflex action, to neighboring nerves or to corresponding nerves upon the other side of the body; for instance, we are all familiar with the fact that a carious tooth sometimes causes pain in the corresponding tooth on the opposite side. With the pain there are apt to be headache and fever, and occasionally even rigors. The nerve if superficial can be traced as a thick cord which will present a continuous or an interrupted swelling, and its course is sometimes marked by a red line, as in phlebitis or angioleucitis. The local temperature will sometimes rise. There may be sensations of numbness or tingling in the area supplied by the sensory filaments.

This will very likely give rise to a marked hyperesthesia, but if the neuritis persists and is followed by atrophy of the nerve, hyperesthesia will give place to anesthesia. The motor filaments also will be affected, producing twitching and tremors of the muscles, very soon followed by paresis, and finally by complete paralysis, and, as a consequence of this, by muscular wasting. A good example of these symptoms is often seen following inflammation of the seventh nerve as it passes through the canal of Fallopius.

Diagnosis.—From rheumatism a neuritis can be recognized most readily by the fact that the pain occurs in the track of a nerve, and later it can also be differentiated by the sensory, motor, or trophic changes which set in. In ordinary neuralgia the pain is of a very different order, being sharp and shooting and more diffused over the affected area. There is no rise either of the general or of the local temperature, nor is there apt to be any muscular spasm, though occasionally this is seen in neuralgia of the fifth nerve.

Treatment.—The most important remedial measure is absolute rest—not by putting the arm in a sling and the patient on a lounge or in bed, and enjoining rest, but by enforcing rest by the application of a splint. This should be used in all cases unless absolutely impossible. With this, of course, there should be elevation of the part, with the application of heat or cold, whichever is the more grateful to the patient. Sometimes blistering, or even the actual cautery, over the course of the nerve, will be found of value. The constant galvanic current is an excellent remedy. Deep injections of morphine, atropine, cocaine, or chloroform, especially in cases of sciatic neuritis, have proved of great value, while morphine by the mouth may be exhibited in sufficient quantities to give reasonable sleep. But it is precisely in these cases of chronic neuritis that the greatest care must be exercised lest we form and encourage the morphine habit. If anesthesia sets in instead of hyperesthesia, the application of the faradaic current by the electric brush on a carefully dried and dusted skin is the best treatment. Of course the general health must be looked after, with attention to diet, the state of the bowels, sleep, habits, and exercise when this latter is permissible. If the patient is of a rheumatic, gouty, or syphilitic constitution, appropriate treatment must be used for whichever of these conditions may be found. Meantime the muscles must be kept in good trophic condition until the neuritis subsides and the nerve resumes its normal function of conveying the stimulus to the muscles. This is best effected by hot and cold douches, massage, and electricity, continued in many cases for weeks or even months, until the nerves resume their abandoned work. Sometimes, especially in sciatic neuritis, stretching the nerve gives good results when all other means have failed.

SECTION III.—NEURALGIA.

Neuralgia may be described as an acute paroxysm of pain in the area of distribution of a nerve, not uncommonly radiating from this as a center to neighboring parts. The ordinary forms of neuralgia are medical rather than surgical, but they often require treatment by surgical means.

Cause.—The disorder is apt in most cases to follow debility, and especially anemia caused by conditions that affect the constitution, such as fever, neurasthenia, long-continued lactation, etc. Hence neuralgia has well been called “the prayer of the nerves for blood.” Malaria, gout, rheumatism, and occasionally syphilis, will often be found at the bottom of it. Persons of neurotic temperament, and especially those coming from a neurotic family, often fall victims to it. Not uncommonly in such patients the joints suffer; and in young women, especially if the menstrual function is disordered or if there is

any uterine trouble, there may be a serious neuralgia of the breast, which is chiefly annoying by reason of the pain and the frequent suggestion of malignant disease. Local conditions also may occasion it. A carious tooth is often the cause of a severe neuralgia, which, it must be remembered, will manifest itself not uncommonly in the corresponding tooth either of the opposite side or of the other jaw. An aneurysm of the aorta or any other tumor which may press upon an intercostal or other nerve will cause it, and disease of the kidney is often attended with neuralgia of the testicle. The variety of the causes which give rise to neuralgia will suggest to us that a most careful examination should be made of the personal and family history in order to determine the appropriate treatment.

The neuralgias which are most frequently brought to the attention of the surgeon are that form of neuralgia of the fifth nerve known as trifacial neuralgia or *tic douloureux*, sciatica, and the neuralgia of stumps and scars.

TIC DOULOUREUX is so called to distinguish it from "*tic convulsif*," or spasm of the facial muscles, which is sometimes painless and sometimes a symptom of *tic douloureux*.

Cause.—As the disease manifests itself most commonly in the face and teeth, if no cause is found in the face it is apt to be attributed to the teeth. It is not uncommon for patients to be brought to the surgeon who have already lost most or even all of their teeth in the vain hope of arresting the relentless pain. As a rule, as soon as one tooth in which the neuralgia has seemed to be worst has been removed another immediately assumes the prime importance, and so tooth after tooth is needlessly sacrificed. The cause must be sought in the condition of the nerve or its blood-vessels. Microscopical examination will often show a neuritis accompanied even with hemorrhage into the substance of the nerve, but more commonly it will reveal a marked senile sclerosis (Putnam, de Schweinitz, and Horsley). This is in accordance with the fact that the disease rarely attacks persons before middle life, when the changes incident to age have begun. Dana has recently published some investigations which seem to indicate that the cause is not to be sought so much in the connective tissue of the nerve-trunk as in its vessels which have been subject to obliterating arteritis, itself the result of advancing years. Carless has called attention to the fact that the foramen ovale differs greatly in size from nearly a circle seven or eight millimeters in diameter to a mere slit not more than two millimeters broad. This narrowness of the foramen and a similar contraction of the lumen of the infraorbital and inferior dental canals may easily exert increasing pressure as the patient grows older, and so cause a progressive neuralgia. In view of the influence of age as a cause of *tic douloureux*, it is not surprising that very frequently after an operation on the nerve has given relief for a time, the disease, whether due to sclerosis or to obliterating arteritis, will recur in the nerve stump and require another and more radical operation. Similar alterations have been traced in some cases even to the Gasserian ganglion. Cold and dampness are also factors in the production of the disease.

Symptoms.—Scarcely any disease, except possibly tetanus, is more calculated to arouse the sympathies of the attending surgeon than severe *tic douloureux*. The pain is usually described as burning, boring, cutting, or darting. It is evoked by the slightest cause: a breath of air, mastication of the simplest food, attempts to speak or to laugh, even the lightest touch or a slight noise, will produce the most fearful paroxysm of pain, in which the patient will suddenly protect rather than grasp his face with his hands, and will writhe about, moaning or crying aloud with the fierce pain. Each meal

costs him frightful suffering. Only liquid food can be taken, for the slightest attempt to masticate brings on a paroxysm of pain; even the swallowing of liquid is endured only because of the imperious demand of the body for food and drink. While his days are days of misery, his nights are nights of sleepless agony. Sometimes he will be free from the pain, it may be for days or even weeks, but it is sure to return, at longer or shorter intervals, until life becomes a burden.

The **diagnosis** is easy, for there is nothing with which such a terribly painful disease can be confounded.

SCIATICA, or neuralgia of the sciatic nerve, often from a true neuritis, is not unusual. Its symptoms are obvious, and the diagnosis, as a rule, is easy.

NEURALGIA OF STUMPS AND SCARS.—Sometimes after an amputation or an operation the stump or the scar will become the seat of severe neuralgic pains. While not so severe as those of *tic douloureux*, they are sufficient to render life miserable. The wearing of an artificial limb is sometimes made impossible, as even light touching of the stump will produce severe pain. Gradually increasing pressure is often better borne than light pressure. In stumps it is the general rule that the cut ends of the nerves become bulbous—that is, develop neuromata (Fig. 136)—and it is believed that these are probably the cause of the pain. In scars the entanglement of small terminal filaments of the nerves is thought to be the cause. Occasionally in either case a true neuritis is set up.

Treatment of Neuralgia.—The first thing to determine is the cause, if this be possible. If the patient be the subject of malaria, quinine in full doses, up to 20 or even 30 grains a day, and in anemia iron, quinine, and cod-liver oil generously given will often be of use. If these fail, arsenic may be pushed to its physiological effect, while strychnine and gelsemium will be found of value. If the patient be subject to gout or rheumatism, colchicum, the alkalies, the salicylates, or the iodide of potassium will be indicated, and in syphilis the iodide of potassium, and sometimes mercury, will give relief. Locally much can be done to benefit the patient. If the nerve itself be tender, sometimes leeching will bring relief. Heat or cold, whichever is more grateful to the patient, even the application of freezing mixtures over the nerve, especially at the tender spots, may be useful. The application of the ointment of belladonna or veratrine, the menthol pencil, the application of croton chloral, and occasionally the Paquelin cauterly, will be of use. The long-continued daily use of the constant galvanic current has often done good. Of course the whole system should be built up by the best and most easily digested food, with regulation of the bowels and the secretions and attention to the habits of the patient. In women the menstrual function and the condition of the uterus and ovaries should be ascertained and any necessary treatment be adopted. Occasionally, however, the patient may be more benefited by a change of climate, surroundings, occupation, etc. than by treatment with drugs. There is a great temptation in rebellious cases to resort to the use of alcohol or morphine, either by the mouth or hypodermatically, but these remedies are dangerous, and the latter too often makes the patient the victim of the morphine habit, the consequences of which are worse than the disease for which relief is sought.

In neuralgia of the joints, absolute rest by means of a splint, or more commonly exercise, massage, the hot and cold douche, and electricity in some of its forms, are the best remedies. In neuralgia of the breast it is very important to calm the patient's fears as to malignant disease. Nervous tonics and sedatives, such as valerian, the bromides, asafetida, strychnine, iron, arse-

nic, and quinine, will be found useful, as will also gentle massage with any of the simpler ointments.

I. Surgical Treatment of Tic Douloureux.—Most of the drugs above mentioned will probably have already been tried. If not, they should be used fearlessly, combined, as a rule, with heat or cold and the constant current or other form of electricity. The extraction of the teeth, as a rule, is to be condemned. Ordinarily all that is left for the surgeon to do is to proceed at once to operation.

The operation for the removal of the nerves will be described later. Though sometimes permanent, the relief obtained by such an excision, as a rule, will be only temporary; yet it is such a boon to the exhausted sufferer that it should always be given when other means have failed. One, two, or three years after the operation the patient will return with his neuralgia almost or quite as bad as before. But the case is by no means hopeless. Sometimes internal remedies or local applications, especially of the constant current, will again give relief, and if not, a second operation can be done for the removal of the stump of the nerve. In some cases where there is no stump of the nerve left, simply the seizing of the fibrous tissues at the point of the former excision and their avulsion will bring a prolonged freedom from pain. This may be repeated more than once. If the entire trunk of the superior maxillary has been removed far back in the orbit, the second operation will consist in the removal of Meckel's ganglion. Recently Rose, Hartley, and others have gone even farther back and removed the Gasserian ganglion itself. (See Operations on Nerves.)

II. Surgical Treatment of Sciatica, Neuralgia of the Brachial Plexus, etc.—In cases of inveterate neuralgia—for instance, of the brachial plexus or its branches or of the sciatic or other nerves—the remedies and drugs above described are first to be employed. When these have failed, surgery still offers relief. Nerve-stretching (neurectasy) has been adopted in very many cases with excellent results. (See Operations on Nerves.) Even when this has failed we are not at the end of our resources. In a few cases where the pain has resisted all other means of cure the spine has been opened, the cord has been exposed, and the posterior or sensory roots of the implicated nerves have been excised, by Abbe and others. (See chapter on the Spine.) But the number of cases is as yet too small and the time that has elapsed too short for the expression of any final opinion as to the advisability of the operation. The pain in such cases is so severe, however, that any operation that holds out even a slight prospect of cure should be deemed admissible unless further experience should show it to be unwise.

III. Surgical Treatment of Neuralgia and of Scars and Stumps.—If a known nerve is caught in a scar an incision should be made and the nerve liberated from the cicatrix. If mere incision and liberation bring no relief, a second operation should be done for the excision of the nerve. If no known nerve is involved, but the pain probably comes from a small unnamed filament entangled in the meshes of the irregular scar following, for example, a lacerated wound, a burn, or a scald, the entire scar should be excised. The linear scar which replaces the irregular and contractile cicatricial tissue of the original scar is much less likely to give rise to such neuralgia.

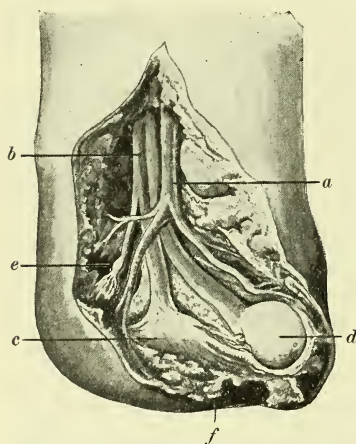
In stumps two methods of treatment may be adopted, of course after the medical means above described have been exhausted. The cicatrix of the stump should be excised and the bulbous ends of the nerves be sought for, drawn down, and severed with a clean cut of a sharp knife. If this does not give relief a re-amputation should be done. Sometimes, as, for instance, after amputation of the distal phalanx of the thumb, where the part is supplied by

known nerves, a portion of each of these nerves should be excised; if this does not relieve, as is too often the case, a re-amputation may be required. Not uncommonly, however, such secondary stumps themselves will be painful, and the resources of the surgeon will be taxed to the utmost to effect a cure. It is very likely that in these cases an ascending neuritis has been developed, and if this can be diagnosed a portion of the painful nerve may be excised in its continuity as high up as the tenderness is traced, unless such high excision of the nerve would produce results so serious as to contraindicate operation.

SECTION IV. TUMORS OF NERVES.

A distinction must be drawn between tumors which are *in* a nerve and tumors which are *on* or *attached to* a nerve, for some tumors are developed in the nerve-fibrils which make up the nerve, while others are mere extrinsic growths. The first class cannot, as a rule, be removed without entire excision of the nerve itself. Those developed on the outside of the nerve may be removed without injury to the nerve. If, however, severe neuralgic symptoms have continued after removal of the growth, it will be best, as a rule, to excise the portion of the nerve to which it is attached, stretch the two ends of the nerve, and reunite them.

FIG. 136.



Neuromata in a Stump after Amputation of the foot: *a*, posterior tibial artery; *b*, posterior tibial nerve; *c*, flat neuroma of internal plantar nerve; *d*, round neuroma of same nerve; *e*, another small neuroma; *f*, cicatrix of stump (Duplay and Reclus).

Tumors developed in the nerves themselves are called **neuromata** (Fig. 136). True neuromata, other than the bulbous ends of cut nerves, made up of nerve-fibers themselves, are very rare. They are usually made up of amyelinic fibers—*i. e.* fibers which have no myeline within the sheath. After the division of a nerve, either by exsection of a portion of it or in an amputation, the proximal ends almost always become bulbous: so frequently does this occur that it may be regarded as a rule. These tumors have been called false neuromata—*i. e.* tumors not made up of nerve-tubules, but of fibrous tissue; but Bowlby has shown that at least in some cases a number of true nerve-fibers are found in them. The neuromata occurring in the trunks of nerves are generally composed of fibrous tissue. Occasionally they are sarcomata or cysts. While they are usually single or exist in very small numbers, instances have been recorded in which even hundreds existed.

Symptoms.—When occurring in the course of a nerve such a tumor frequently gives rise to no symptoms whatever, and may even be unsuspected until revealed by a post-mortem. More commonly, however, it excites such neuralgic pains as to lead to an examination of the part, and if the nerve lie superficially the tumor may be detected. If not, it causes spasms from irritation or paralysis from pressure, while trophic lesions of the muscles, skin, and other parts supplied by the nerves are often seen. (See Injuries of Nerves.)

Treatment.—If such neuromata produce no pain or other serious symptoms, they should not be interfered with. If any serious symptoms arise, the tumor, with the portion of the nerve in which it is developed, should be removed. If the two ends can be approximated by stretching, immediate suture should be practised, but if they cannot be brought together the gap may be supplied

by the transplantation of a suitable portion of a nerve from one of the lower animals or from a newly-amputated limb. It is even possible, when the ends cannot be approximated, that if they can be sutured together with catgut threads, thus bridging the interval between the two ends, the nerve may be regenerated. Van Lair makes use of a cylinder of decalcified bone to carry the catgut between the ends. In the painful neuromata which develop in nerves after their section or in stumps after amputation, after exhaustion of the medical means the part should be opened, the nerves dissected out, and the bulbous extremities resected.

Painful Subcutaneous Tubercle.—A peculiar form of tumor connected with a nerve is known by this name. It is generally single; as its name indicates, it is small, often about the size of a pea; it lies immediately under the skin and is connected with a sensory filament of a cutaneous nerve. It is usually made up of fibrous tissue. One symptom which distinguishes it from all other tumors is its excessive tenderness and pain. This pain extends up and down the limb, and is sometimes generalized, occasionally accompanied with spasm of the muscles. The pain appears in paroxysms of greater or lesser duration. The **treatment** is excision of the tumor, together with the portion of nerve-tissue in which it grows. The resulting anesthesia will disappear in time.

SECTION V.—WOUNDS AND INJURIES OF NERVES.

These are not uncommon. They are seen more frequently in the upper extremities than in the lower, the nerve-trunks being anatomically more exposed in the arm and also more frequently subjected to violence. Contusion and compression are the most frequent injuries. Wounds may be either clean-cut incised wounds or more or less extensive lacerated or contused wounds, such as those caused by missiles of war, those which result from railroad and machinery accidents, punctured wounds, and the like.

I. CONTUSIONS and COMPRESSION OF NERVES.—Nerves suffer from contusions, occasionally from direct blows, as on the ulnar nerve at the bend of the elbow or on the brachial plexus in the neck. In addition to this, dislocations, especially of the head of the humerus in the axilla, often produce serious contusions and compression, as will also, though more rarely, the attempt at reduction by placing the unbooted heel in the axilla. Dislocations, and especially fractures near the elbow, are liable to produce contusions and sometimes laceration of the ulnar or musculo-spiral nerves. In fracture of the humerus the musculo-spiral nerve is apt to be contused, compressed, or wounded, and the brachial plexus may be similarly injured in fracture of the clavicle. Fracture of the pelvis through the sciatic notch has resulted in like injury to the sciatic nerve at its point of emergence. There are also some forms of steady or repeated compression which produce trouble. Sometimes, though rarely, the excessive growth of callus has been thought to cause the pressure. Tumors cause it not very uncommonly, especially thoracic aneurysms. The use of crutches, especially if not well padded, produces a form of palsy known as "crutch palsy." This will be more common, of course, in heavy persons. Lying in peculiar positions, especially with one or both arms under the head, particularly in the deep sleep of drunkards, will sometimes give rise to a similar palsy. The pressure of the forceps on the seventh nerve during delivery sometimes produces facial palsy in the child, and in addition to this the pelvic nerves of the mother may be injured from prolonged pressure by the foetal head in delayed deliveries. In all these cases the nerve suffers mechanically to a greater or lesser extent, and the fibers are apt to be torn or pressed together; occasionally hemorrhage

into the substance of the nerve occurs, while the myeline is more or less mechanically disturbed. In severe cases of contusion or compression there will be of course entire mechanical destruction of the nerve.

Symptoms.—These will vary in accordance with the severity of the injury. If it be slight the symptoms will resemble the common phenomena produced when the ulnar nerve is struck at the elbow, which is known as striking the “crazy bone” or the “funny bone.” This is generally attended with tingling and a sense of “pins and needles” in the ulnar distribution. Loss of function is not apt to follow immediately unless the contusion has been violent. Occasionally, however, apparently a severe neuritis will follow, with pain in the distribution of the nerve and possibly palsy of the muscles supplied, and trophic alterations in the skin and its appendages.

Treatment.—This will depend on the cause. If it be the pressure by a tumor or by the dislocated head of the humerus or from a fracture, first of all the cause must be removed if possible. The next most important indication is that the nerve shall have absolute rest,—not rest merely by non-use of the part, but rest by means of a splint, and, if the contused nerve be in the lower extremity, rest in bed in addition to the splint. In cases of moderate injury this perhaps is all that will be required, with possibly the local abstraction of blood by means of leeches and cups. If the injury be more severe, the injection of morphine, with or without atropine, or its administration by the mouth, in order to quiet the pain, is generally indicated. Arsenic is sometimes of value, and the repeated application of galvanism in obstinate cases may give relief. The remote symptoms, motor, sensory, and trophic, are to be treated as is described under the head of Wounds.

II. WOUNDS OF NERVES.—Formerly division of the small nerves at the bend of the elbow was very common from the promiscuous bleeding then in vogue. At present by far the commonest wounds of nerves are from glass—as, for instance, from thrusting the hand through a pane of glass or from the breaking of a glass bottle—and from knives, scythes, etc., while the ordinary accidents of civil life, such as punctured wounds by needles, scissors, and splinters, and the more extensive lacerated wounds following railroad and machinery accidents, are of frequent occurrence. In military practice and occasionally in civil life the nerves are implicated in gunshot wounds. The damage done to motion and sensation is most severe after wounds of the larger nerve-trunks; but the reflex symptoms from such wounds are more commonly seen when the smaller filaments are implicated, and more often after laceration or puncture than after a clean cut.

Symptoms.—The symptoms of a nerve wound are not distinctive of the nature of the injury, whether it be a contusion, a clean incision, or a lacerated or gunshot wound. The immediate symptoms are both local and constitutional, and vary to the greatest possible degree in their severity. The pain may be so slight in some cases that the wound will escape notice, or at most the patient will imagine he has been struck by a stick or stone. In other instances the pain even from the wound of a small nerve will be so severe that he will lose consciousness from it. This condition of shock will sometimes be very great, especially in gunshot wounds. It need not be described here, for it resembles the shock of other wounds.

In one respect, however, a further statement is necessary,—namely, as to the so-called “reflex palsies.” In a number of instances it has been noted that the wound of a small nerve (for it is more common in a small nerve than in a large one), for instance, on the right side of the neck, will produce a palsy of the left arm or left leg or of both; or a wound of the thigh may produce paral-

ysis of the arm or leg of the opposite side of the body, or sometimes of all four limbs. This has been explained by Brown-Séquard on the theory of reflex paralysis or spasm of the vessels of the paralyzed limb or limbs themselves, but the theory advanced by Mitchell, Morehouse, and Keen, that it is due to exhaustion of the nerve-centers of motion and sensation, seems to be the better explanation.

Shock and pain, with loss of motion or of sensation, or of both, are then the immediate symptoms of nerve wounds. Such wounds are of course attended with more or less hemorrhage, and are subject to the same danger of infection and inflammation that attends wounds elsewhere or of other organs.

It is, however, the remote symptoms and results of nerve wounds that are by far the more important and interesting and constitute their peculiarity. They were first carefully studied in our late civil war by Mitchell, Morehouse, and Keen. Sensation and motion are sometimes equally affected; but sensation is apt to be less affected than motion, and if both are affected, sensation, as a rule, will return earlier than motion. If the nerve be a motor or a mixed nerve and its function be destroyed, the muscles which it supplies will soon show marked wasting, together with increasing feebleness of action, or not uncommonly complete palsy; and as a later result contracture of the muscles will follow, giving rise not only to inability to use the part, but also to serious deformity. Combined with the motor disturbances there will be marked alterations of sensation, and the skin supplied by the nerve will become anesthetic or frequently hyperesthetic and painful.

A third series of changes in the nutrition of the parts supplied by the nerve follows, usually at a considerable time after the sensory and motor changes. These trophic changes do not take place at the seat of the wound, but at a distance from it, in the area to which the nerve is distributed. They manifest themselves first in a curious appearance of the skin, which looks as if it were varnished. It is usually red and is very apt to be dry, though sometimes it will be bedewed with perspiration, which is often acid and foul-smelling. Along with this there is sometimes developed a burning pain, which Mitchell has named "causalgia." Frequently even to point at the injured hand of such a patient will evoke such a paroxysm of pain that he will draw his hand away in fear. In many cases he obtains relief from wetting the injured hand or foot, and may even wear a cotton glove which he will constantly wet, or may pour water into his boots in order to keep the burning foot in even moderate comfort. The hair is commonly greatly diminished in amount. The nails become strangely curved, both in the axis of the limb and transversely, showing furrows and ridges, and very often ulceration of the matrix occurs. Sometimes gangrene of the terminal phalanges of the fingers and toes will set in, and may extend more widely, but not often beyond the fingers or toes. There is often also an eruption like chilblains or eczema. Sometimes the larger joints will become inflamed, swollen, and tender after a wound of the main nerve or nerves of a limb. These neural arthropathies follow not only wounds or other lesions of nerves, but also injuries to the central nervous system, either in the spine or in the brain. They resemble rheumatic arthritis to a marked degree.

Diagnosis.—(1) *As to Motion.*—In making a diagnosis of the loss of motion that follows injury to any nerve it is only necessary to determine what muscles have lost their function and to compare these muscles with the nerves which supply them. In order to test the strength of the muscles of the forearm as a whole, the dynamometer must be used. This is simply an oval spring with a graduated disc and a movable pointer. On grasping it the registration by the pointer on the graduated scale shows the relative strength of the two

arms. There should be similar instruments to test the force of the motions at the elbow, wrist, shoulder, and leg, but none such have been devised.

(2) *As to Sensation.*—Here the problem is a much more difficult one, not only because the nerve-supply of the skin is by no means so constant as that of the muscles, but also because the methods involved require greater attention. The loss of sensation in the skin varies considerably in its character. In a certain area there will be absolute loss of sensation, or anesthesia. Between this and the area of normal sensation is a zone of irregular outline in which sensation is not absent, but perverted. This is the region of *dysesthesia* or *paresthesia*, and will vary much in different cases. It must be remembered that there is also what has been called “supplementary sensation.” By this is meant that the entire area ordinarily supplied by a certain nerve, which should be entirely anesthetic after division of its nerve, is still found to possess a more or less complete sensation after such division. Whether this is from anastomoses of neighboring nerves or not is a problem which is as yet not solved. To aid in its solution, in all cases in which a nerve has been purposely cut or has been divided by accident the areas of full sensation, paresthesia, and anesthesia should be carefully mapped out by the methods described below and the areas indicated, that of total anesthesia by dark shading, that of paresthesia by lighter shading. Only by collecting and comparing numerous reports of such cases can the physiological anatomy of the nerves be determined.

In determining the areas of anesthesia and paresthesia the surgeon should be careful not to rub the part nor adopt any other rude method of testing, for any displacement of the skin is perceived readily at a distance. The best methods are as follows: First, by a light pencil, or in some cases a feather or bristle or any other means of delicate touch, the area, for instance, of anesthesia is determined from point to point, and is mapped out. Sometimes for still more delicate determination the mere touching of the hairs that grow so plentifully over most of the body can be used. An additional means is the ability of the patient to recognize the points of a pair of compasses as two points or as one. The pair of compasses is fitted with a graduated scale indicating the distance between the two points, either in inches or centimeters, and is called an esthesiometer. The best are now provided with a small knobbed point and a sharp point to each arm of the compasses. An ordinary pair of compasses and a graduated ruler, however, will answer. In using them it is important that the test be made alternately on the two corresponding limbs under the same conditions and with the same number of repetitions, and that, for proper comparison, it be done in each limb either transversely or in its long axis, for the ability to distinguish the two points varies with the number of repetitions and with the placing of the points transversely or lengthwise. It is especially needful to see that the two points touch the skin simultaneously, for two successive touches would of course be appreciated as two points, even when if touched simultaneously they would be perceived as only one. All these examinations should be made with the patient blindfolded, so as to prevent the assistance of sight, and he should not be allowed to move the fingers, toes, or other parts in order to assist sensation by the muscular sense. It must be remembered also that normally many persons cannot distinguish well between adjacent toes, especially the third and fourth. Where sensation has been lost to ordinary touch it will still be retained to certain other stimuli, as, for example, electricity, and these also may be used as a means of diagnosis. The electric wire brush will evoke sensation in many cases where all other means fail. The sense of temperature should also be determined by dipping the hands or feet into water of a known temperature, or by applying mops dipped in the water, in many

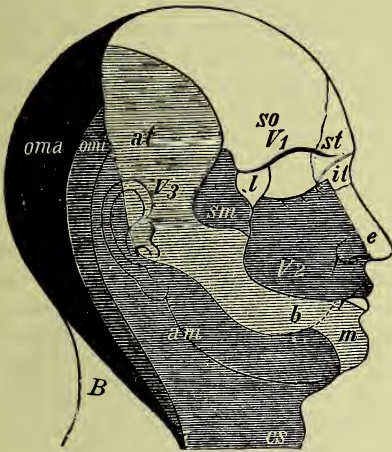
cases using alternately hot and cold water. As a rule, it will be found that while sensation and motion may be equally lost at the time of injury, sensation will return, sometimes shortly, sometimes at a longer interval, before motion. Generally also the irritability of the muscles to the constant galvanic current is lost some time after their response to faradaic electricity, the return of electro-muscular contractility being in the reverse order. Voluntary control over the muscles is, as a rule, lost before response to electricity, and returns in reverse order.

DIAGNOSIS OF LESIONS OF SPECIAL NERVES.

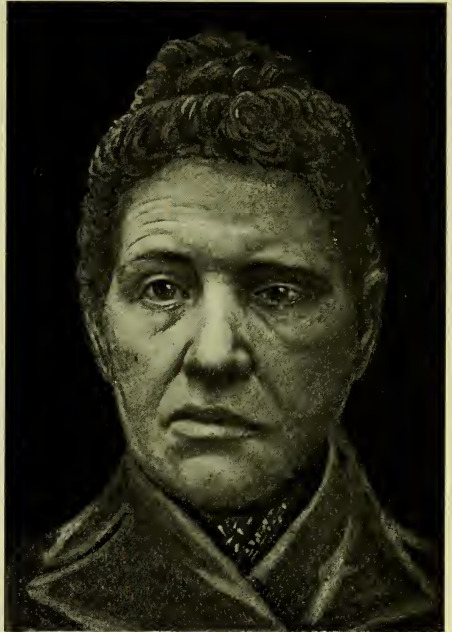
I. Fifth or Trifacial Nerve.—Figure 137 shows the cutaneous distribution of the three branches of the fifth nerve (V_1 , V_2 , and V_3) in different shadings. From a determination of

FIG. 138.

FIG. 137.



Distribution of the Cutaneous Sensitive Nerves upon the Head: *oma*, *omi*, the occipit. maj. and minor (from the N. cervical. II. and III.); *am*, N. auricular. magn. (from N. cervic. III.); *cs*, N. cervical. superfic. (from N. cervic. III.); V_1 , first branch of the fifth (*so*, N. supraorbit.; *st*, N. supratrochl.; *il*, N. infratrochl.; *e*, N. ethmoid.; *l*, N. lachrymal.); V_2 , second branch of the fifth (*sm*, N. subcutan. mæle seu zygomaticus); V_3 , third branch of the fifth (*at*, N. auriculo-tempor.); *b*, N. buccinator; *m*, N. mental.; *B*, posterior branches of the cervical nerves (Seeligmüller).



Paralysis of Left Facial Nerve, the face being in repose (original).

the region of hyperesthesia or anesthesia the particular branch involved can be ascertained.

II. The Facial Nerve may be injured in gunshot wounds, in fracture of the middle fossa, or in necrosis of the petrous portion of the temporal bone, and may also be divided by the surgeon in the removal of tumors from the parotid and neighboring regions. If the injury be far enough back to involve the chorda tympani, taste will be impaired. The palsy which follows injury of the facial nerve is pathognomonic. The eyebrow cannot be raised or wrinkled horizontally, and the eyelids can be only partially closed. But the patient soon learns to roll the ball up under the upper lid in order to wet the cornea and preserve its translucency. The ala of the nose on the paralyzed side does not move in respiration nor by volition, and control of the angle of the mouth is lost, saliva and other liquids dribbling from it. The patient cannot pucker his mouth to whistle. The entire face on the side of the lesion has an expressionless stare. When the patient attempts to laugh or to close the eyes tightly, only

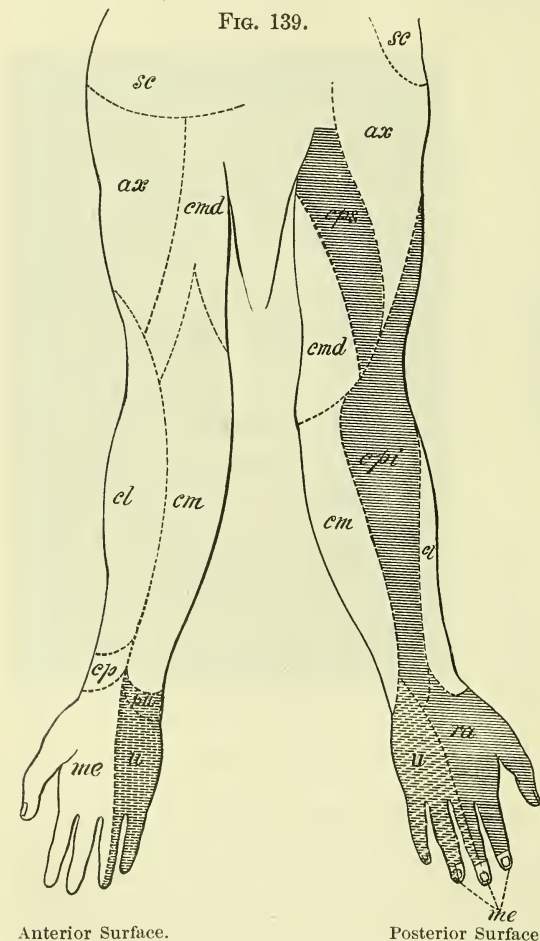
the unparalyzed side of the face is wrinkled, the other remains smooth. The facial being purely a motor nerve, no change of sensation occurs.

III. The Pneumogastric and its Recurrent Laryngeal Branch.—

In a very few cases in tying the carotid or in the extirpation of tumors the pneumogastric has either been divided or ligated, and in the excision of goitre one of the chief dangers is the division of the recurrent laryngeal. Either lesion produces hoarseness and altered voice from paralysis of the vocal cord on that side, and if in the excision of goitre the nerves be cut bilaterally instant tracheotomy must be done to prevent suffocation. Except alteration of the voice, the effects of section of the pneumogastric or its ligation seem to be extraordinarily slight.

IV. The Ulnar Nerve.—This is cut most frequently just above the wrist. It may also be divided at the elbow or in the upper arm. The *motor*

paralysis will affect the flexor carpi ulnaris, the inner half of the flexor profundus in the forearm, and in the hand the whole group of hypothenar muscles, the two ulnar lumbrical muscles, all the interossei, the adductor pollicis, and half of the flexor brevis pollicis. The appearance and action of the hand in ulnar paralysis are therefore very characteristic. Besides the wasting of the ulnar muscles in the forearm, the hypothenar eminence is wasted and may become even hollowed, and there is partial wasting of the thenar eminence. The interosseous spaces also are furrowed from the wasting of these muscles. If an object be placed in the palm and the patient be told to grasp it, he will first flex the last two phalanges of the fingers by the common flexors, and then by the further contraction of these muscles will roll the flexed fingers into the palm, but he will not be able to grasp an object by placing the tips of the fingers on the thenar and the hypothenar eminence by flexion at the knuckle, as can be done in the normal hand. Moreover, as the interosseous and lumbrical muscles extend the last two phalanges of the fingers,



Anterior Surface.

Posterior Surface.

Distribution of the cutaneous nerves to the shoulder, arm, and hand. The region of the N. radialis is represented by the unbroken hatched line, that of the N. ulnaris by the broken hatched lines. *a*, anterior, *b*, posterior surface; *sc*, Nn. supraclavicular. (plexus cervicalis); *ax*, chief branch of N. axillar.; *cps*, *cpi*, Nn. cutanei post. sup. and inf. (from N. radialis); *ra*, terminal branches of N. radialis; *cm*, *cl*, Nn. cutanei medius (also to the plexus) and lateralis (chiefly to the N. medianus); *cp*, N. cutan. palmar.; *me*, N. rad.; *cmd*, N. cutan. medialis; *me*, N. medianus; *u*, N. ulnaris; *cpu*, N. cutan. palm. ulnaris (Henle).

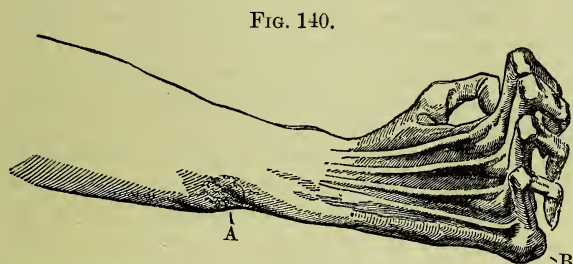
these joints of the fingers will remain constantly in semiflexion, while

the first phalanges will be pulled backward in marked extension by the now unopposed common extensor.

As a result of this the "claw hand" is produced, and all the more delicate motions of the hand are lost. Fig. 140 shows an extremely bad case. The

scar of the wound of the ulnar nerve is seen at A. A lesion of this nerve is therefore of very serious importance to any patient, whether he be laborer, artisan, or in the higher classes of life.

Sensation.—As a rule, the ulnar nerve supplies the ulnar portion of the skin of the hand both front and back, the entire little finger, and the ulnar half of the

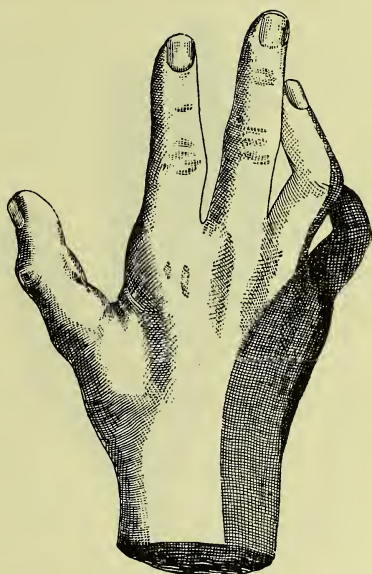
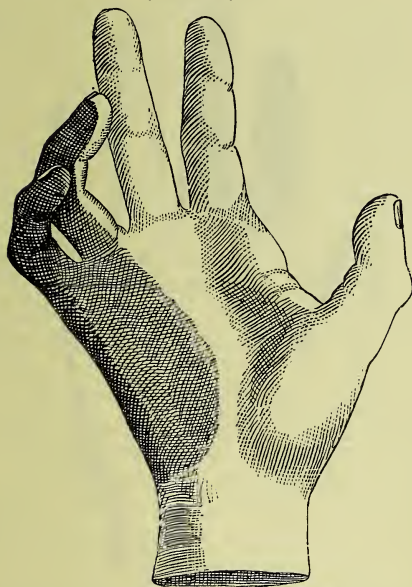


Paralysis of Ulnar Nerve from Wound at A; contracture of common extensor with posterior luxation of first phalanges; B, head of metacarpal bone (Duchenne).

ring finger; but at the tip of the finger the median nerve invades somewhat

FIG. 141.

FIG. 142.



Loss of Sensation on anterior and posterior surfaces of hand after division of the ulnar nerve (Bowlby).

the otherwise mathematical distribution of the ulnar. There are, however, in this region marked differences in different patients.

V. The **Median Nerve** also is most frequently divided just above the wrist, where it is comparatively superficial, the flexor tendons being often involved in the injury. It may be injured also higher up on the forearm or at any point in the arm.

Motion.—The motor symptoms will depend on the point where the nerve is injured or cut. If the median be divided above the elbow, all the flexors and pronators of the arm, with the exception of the flexor carpi ulnaris and the ulnar half of the flexor profundus, will be paralyzed. All the muscles of the thumb, except the adductor and half of the flexor brevis pollicis, will be

paralyzed. In both this and in ulnar paralysis flexion of the wrist is lost on the radial or ulnar side respectively, but remains on the opposite side of the forearm. The hand cannot be pronated except by its own weight. Flexion of the thumb is lost in the distal phalanx and weakened in the proximal, and, what is still more important, the thumb cannot be opposed to the other fingers. The last two phalanges of each of the fingers cannot be flexed, while flexion at the knuckles still remains by the action of the interosseous muscles. If the injury be at the wrist, the muscles of the forearm will escape, the fingers can be flexed, but the thumb still cannot be opposed to the other fingers, and hence small objects can neither be picked up by the thumb and the tips of the fingers nor be well grasped and retained. The appearance is again typical. Wasting of the forearm is more marked than in ulnar paralysis, and the hand is in partial flexion to the ulnar side, with extension of the wrist and fingers. While the hypothenar eminence is not wasted, the thenar eminence is almost gone. This too, it will be seen, is a very serious accident in any station in life.

Sensation.—On the palmar surface the area of anesthesia or paresthesia includes the radial half of the palm and the palmar surface of the thumb, index, and middle finger, and the radial side of the ring finger, including the major part

FIG. 143.

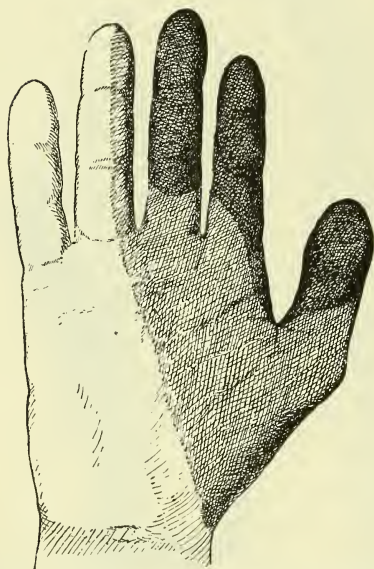
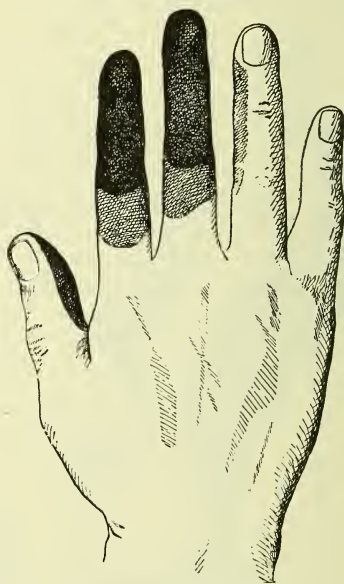


FIG. 144.



Section of Median Nerve: areas of anesthesia (heavy shading) and of dysesthesia (light shading) on palmar surface of hand (Bowlby).

Section of Median Nerve: regions of anesthesia and dysesthesia on dorsal surface of hand (Bowlby).

of its tip. Posteriorly, nearly the whole of the fore and middle fingers becomes anesthetic, and the radial side of the ring finger, but little or none of the dorsal surface of the hand.

VI. Radial Nerve.—This is divided occasionally as it passes over the front of the forearm to the back of the hand just above the wrist. No muscles are supplied by it. The region supplied by it with sensation, and therefore anesthetic after its section, is a portion of the skin over the metacarpal bones and first phalanges of the thumb and the forefinger.

VII. The Musculo-spiral Nerve.—This is most frequently injured by gunshot wounds or fracture of the humerus involving the musculo-spiral groove.

Motion.—If the nerve is paralyzed below the branch going to the supinator longus, this muscle escapes paralysis and its function as a flexor of the forearm becomes very marked. If the nerve is injured above the origin of this branch, the supinator longus is paralyzed, and flexion and supination are impaired, though not lost, for the biceps acts as a marked supinator as well as flexor, and is aided by the supinator brevis. Extension of the wrist and fingers is lost, and there is distinct wrist-drop, with inability to extend the fingers at the knuckle (Fig. 145). The last two phalanges, however, can still be extended by the interosseous and lumbrical muscles. Atrophy of the extensors is very marked.

Sensation.—The loss of sensation will differ, depending on the level at which the nerve is injured.

Several of the above nerves may be injured at one time, or the brachial plexus itself may be ruptured in accidents and occasionally in surgical operations.

VIII. The Great Sciatic Nerve.—Since it is so well protected, the trunk of the sciatic is not often injured or cut by accident, except in gunshot wounds, but its external popliteal branch is sometimes divided in tenotomy of the biceps muscle or accidentally just below the head of the fibula.

Motion.—The importance of this branch lies in the fact that it supplies the anterior flexor muscles of the foot, and that its injury or division is followed by *foot-drop*, so that the foot drags in walking and the wearing away of the boot-sole under the great toe is very marked. If the main trunk of the sciatic is divided or injured, all the muscles below the knee are involved in the paralysis. The patient can walk, because, as a rule, the muscles of the thigh are not involved, but the leg is, as it were, flung forward from the hip at each step.

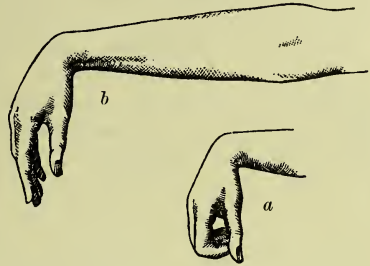
The loss of *sensation* (Fig. 146) is generally less extensive than the loss of motion, only the foot and the outer parts of the leg being entirely anesthetic.

Prognosis after Injuries of Nerves.—This is more or less grave in accordance with the importance of the nerve involved, the extent of the injury, and the time that has elapsed without proper treatment. It is, however, possible, after a lapse of months or sometimes even of years, to do much in the way of restoration, sensation being, as a rule, more under control than motion. If the time has been long and the injury severe, good results can be attained only after treatment covering weeks or months, and in many cases can scarcely be hoped for. Hence the especial need for the early correct treatment of these injuries.

Treatment of Wounds of Nerves.—The fact that there is a lesion of a nerve will not modify the primary treatment of the wound unless the nerve be amenable to suture, as described below. This should always be done at the time of the accident. The wound should be treated in other respects precisely as any ordinary case. The treatment of the remote results due to nerve injury are, however, somewhat peculiar, and are now to be considered.

Treatment of the Remote Effects following Nerve Injury.—1. **Motion.**—Unquestionably the agent which gives us the best promise of relief from a destructive motor lesion is electricity. When a motor or a mixed nerve

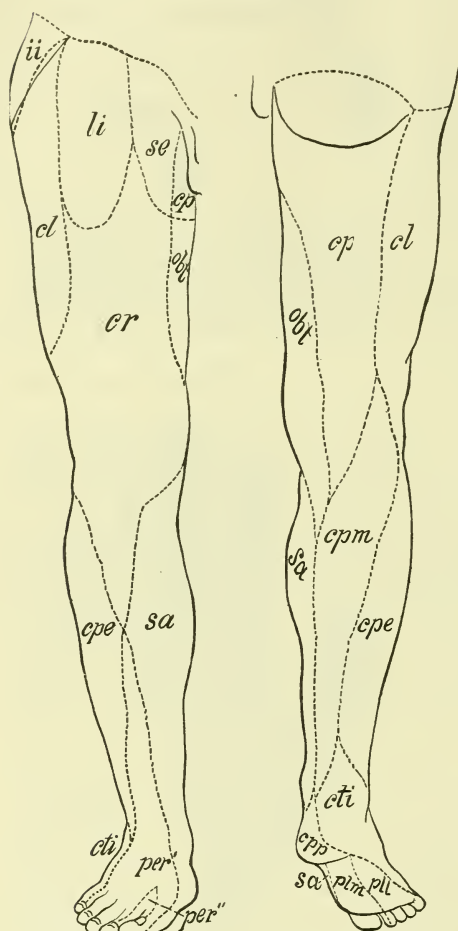
FIG. 145.



Paralysis of Musculo-spiral Nerve after Fracture of the Humerus ("wrist-drop"); but when fingers have been flexed into palm, *a*, they can be extended *b*, at first interphalangeal joints by lumbricals and interossei, which are supplied by the ulnar and median nerves (Erichsen).

has been divided, as has already been stated, the muscles which have been paralyzed very soon indicate degenerative changes affecting their nutrition and producing a permanent shortening. This degeneration can be prevented to a large extent by the daily or almost daily use of electricity, which will keep

FIG. 146.



Anterior Surface.

Posterior Surface.

Distribution of the cutaneous nerves of the lower extremity. *ii*, N. ilio-inguinal. (plex. lumb.); *li*, N. lumbo-inguinal. (to the genito-crural, plex. lumbal.); *se*, N. spermat. ext. (to the genito-crural.); *cp*, N. cutan. post. (plex. ischiad.); *cl*, N. cutan. lateral. (plex. lumb.); *cr*, N. cruralis (plex. lumbal.); *obt*, N. obturator. (plex. lumb.); *sa*, N. saphen. (plex. lumbal.); *cpe*, N. commun. peron. (N. peron. tibial.); *cti*, N. commun. tibial.; *per*, *per'*, N. peronæi ram. superfic. et prof.; *cpm*, N. cutan. post. med. (plex. ischiad.); *cpi*, N. cut. plant. propr. (N. tib.); *plm*, *pl*, N. plantar. medial. et lateral. (N. tib.) (Henle).

the muscles in their normal condition, ready to resume their natural function by volition on the rehabilitation of the nerve-trunk, which may then take the place of the electric stimulus. If the nerve responds to faradism, this is undoubtedly the best form to use. If, however, so much time has elapsed that the muscles do not respond to faradism, galvanism should be employed and the effect of faradism re-tested from time to time, and as soon as the muscles respond to faradism this should be used in preference. An important adjunct to this is systematic daily massage of the paralyzed limb, which should be persistently employed with the same object as the use of electricity. The hot and the cold douche should also be used, together with such general measures as will best keep up the general health. If muscular spasms occur, the injection of $\frac{1}{150}$ of a grain of atropine deep into the substance of the muscle is the best means of overcoming the spasm. If deformities have resulted, tenotomy is often indicated and will result beneficially. If the joints have become ankylosed or otherwise diseased, the adhesions must be broken up under anesthesia, very often repeatedly, and the joint stimulated to return to its normal condition by passive motion, friction, douches, massage, etc. These efforts must not be relaxed until the lapse of months or even of years has proved that the lesion is beyond relief.

2. *Sensation.*—*Anesthesia.*—The best means of stimulating the skin, apart from the measures already indicated, massage, friction, douche,

etc., is the electric brush. This is best applied with the faradaic current, the skin having first been dried with flour.

Pain.—The pain varies so much in degree that the treatment must be correspondingly varied. Sometimes the simple application of cold water is sufficient. Occasionally the injection of small amounts of morphine will answer

the purpose, and often rest will do much, but in cases of severe pain, especially that named by Mitchell "causalgia," all means employed will sometimes be futile. The patient who is a victim of such pain soon learns the value of cold water and keeps the part constantly wet, wearing a wet glove or pouring water into his boots. The most useful remedy in these cases is repeated blistering over the course of the nerve, and in many instances this will give even complete relief. Morphine should be given by the mouth or by injection, but care must be taken lest the morphine habit be formed. If the pain resists these remedies, especially when combined with those already mentioned, the nerve involved should be stretched, divided, or excised. Sometimes even amputation is required.

SECTION VI.—OPERATIONS ON NERVES.

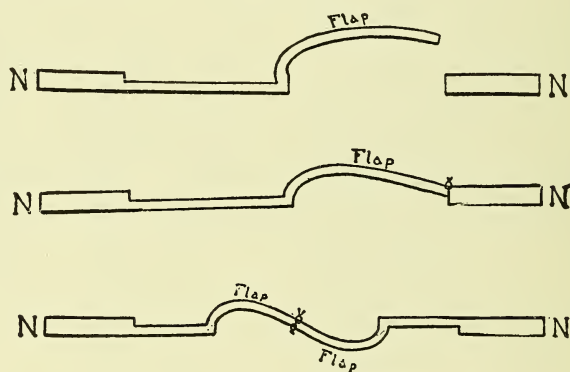
These are four in number: I. Nerve-Suture and Nerve-Grafting; II. Neurectasy, or Nerve-Stretching; III. Neurotomy, or Division of a Nerve; and IV. Neurectomy, or the Excision of a Part of a Nerve.

I. Nerve-Suture and Nerve-Grafting.—*Primary Suture.*—The old views of the dangers of sutures as applied to nerves are entirely exploded, and numerous cases in which suture of a nerve has been practised immediately after the injury prove that recovery of function is greatly facilitated by such suture. Hence, precisely as is the case with a tendon, a nerve should always be sutured immediately if possible, even if the section of the nerve is only partial. Supposing first that the nerve is merely divided, without loss of substance, and that the ends can readily be approximated, two or three sutures should be passed not merely through the sheath of the nerve, but through its substance. These should be preferably of fine silk, and inserted by sewing-needles. The part then should have absolute rest on a splint, so that the nerve-ends should not be torn asunder by motion of the limb. Catgut, kangaroo tendon, etc. may also be used, of course with antiseptic precautions. In one case in which no such means were at hand an ordinary hare-lip pin was inserted obliquely through the two ends of the ulnar nerve and a loop of fine silk thrown over its point, brought out through the wound, and secured to the head of the pin. At the end of three days the pin was withdrawn, thus loosening the silk, which was easily removed. The result was in every way satisfactory. If the ends are so far separated that they cannot be readily approximated, one or both ends of the nerve may be stretched until they can be placed in contact, and the same process then carried out. While failure has occurred in a good many cases, the results have been surprisingly successful in others. In a very few instances apparently primary union has taken place and sensation has been restored in two or three days, or even less; but more frequently one, two, or more weeks will elapse, and we should not despair of such a nerve until months or even years have passed. Bowlby has analyzed 81 cases of primary suture, of which 32 were entirely successful, 34 were partially so, and only 14 were failures, the result in one case not being recorded. It is especially important to remember that we should not be hasty in our conclusions as to results. The early results may be disappointing, but time must be allowed for union, degeneration, and regeneration of the nerve before we can expect return of function in most cases. Even the gravest of trophic changes should not make us despair of the ultimate result. Sensation will return, as a rule, before motion, and, in view of the time that elapses before the nerve will be able to carry the stimulus of volition to the muscles, the value of electricity in keeping the muscles in good condition must especially be borne in mind.

Secondary Suture.—Within the last few years, in a number of cases weeks, months, or even a number of years after the injury, when the muscles have been paralyzed for a long time and sensation has been altered or destroyed, the secondary suture of such divided nerves has been followed by success. This operation, like all others, must be strictly antiseptic. An Esmarch bandage should be applied, the nerve exposed, and the two ends loosened from their attachments. The proximal end will, as a rule, be bulbous and be found with ease. It is often more difficult to find the wasted distal end, and sometimes it is best to cut down on the nerve beyond the site of the injury at a point where the nerve lies in its normal relations, and then follow up the trunk till we come to the cut lower end. The whole of the bulbous extremity of the proximal end should be removed, but only a small portion, usually not over a quarter of an inch, of the distal end. The two ends should then be approximated by stretching, and the nerve sutured as before. Bowlby's table of 73 cases of secondary suture of the nerves gives successful results in 32, partially successful in 26, and failure in only 15.

Nerve-Grafting.—If, after stretching, the ends of the nerve cannot be approximated, two methods are open to us (Fig. 147): partially splitting the

FIG. 147.



Suture of a Nerve by Splitting the Ends (Beach).

nerve for a certain distance, turning over what may be called the flap of nerve, and uniting it to the other cut end; or flaps may be made from both ends (Beach). The results of this method of treatment have not, however, been very satisfactory. Possibly the transplantation or grafting of nerves will give better results. If a nerve can be removed from an amputated limb (the two operations of amputation and nerve-suture being simultaneous), a portion of human nerve can be transplanted. If it be impracticable to obtain a portion of human nerve, a suitable portion of a nerve from one of the lower animals can be removed, placed in its proper position, and sutured at both ends to the cut ends of the nerve. It is probably a matter of indifference whether this nerve be a motor, sensory, or mixed nerve, the nerve-tubules being simply subservient to the transmission of the nervous impulse in either direction. The suggestion of Von Bergmann that the entire limb shall be shortened by resection of a portion of the bone seems superfluous in view of the dangers of the operation as contrasted with those of the simple operation of nerve-grafting by transplantation.

II. *Neurectasy, or Nerve-Stretching*, was first introduced by Nussbaum in 1872. Vogt has shown by experiment that a nerve can be stretched

one-twentieth of its length, and that it yields most at its spinal extremity, the amount of elongation diminishing as we approach the periphery, where it becomes almost nothing. In order to guide us as to how much force we can apply, it is important to know what force will rupture the nerve. Marshall gives the following result of experiments on different nerves:

Cohesion of Human Nerves after Death—Breaking Strain in Pounds.

	Lbs.
Supraorbital	6
Infraorbital	12
Mental	5½
Brachial plexus	50-64
Ulnar	58
Musculo-spiral	61
Median	84
Crural	83
Internal popliteal	114
Great sciatic—Symington	86-176
“ “ Tillaux	118-127
“ “ Gillette	165
“ “ Trombetta	82-288
“ “ Ceccherelli	154-220

It must be remembered that the force necessary to produce rupture is probably somewhat greater in the living than in the dead subject. The nerves most commonly stretched are the facial, the spinal, and the sciatic, especially the latter. It should be noted that the facial nerve, which is not included in Marshall's table, will bear a strain of from seven to twelve pounds, and that therefore the head can be almost lifted from the table, and in some cases entirely so, without rupture of the nerve-trunk. The surgeon generally feels the rupture of some strands, which will warn him of the impending rupture of the entire trunk. The great sciatic nerve has ruptured in various subjects at a minimum of 82 pounds and a maximum of 288. It is therefore, as a rule, absolutely safe to lift the leg or even the pelvis by traction upon this trunk. Whether nerve-stretching produces any traction upon the cord has been much disputed. But Tarnowski has shown experimentally in rabbits that while slight traction on the sciatic nerve was followed by a passing hyperemia, when the traction was considerable hemorrhages in the gray matter and inflammatory exudations were caused, followed by sclerosis and atrophy of the nerve-cells; and marked effects have been noted after stretching of the brachial plexus. Moreover, inasmuch as there are on record at least eleven cases of death from lesion of the spinal cord after nerve-stretching, such deleterious influences can scarcely be denied.

The effects of nerve-stretching are more or less hemorrhage and destruction of the nerve-tubules, differing in amount with the force used, with later cell-proliferation in the neurilemma. This tearing of the nerve-tubules is followed by degeneration precisely as after section of the nerve, followed in turn, however, by a much greater regeneration. In the cord the changes are usually inflammatory, from a slight hyperemia up to a definite myelitis followed by atrophy. The direction of the stretching is not a matter of indifference, for, as shown by Tutschek, if a nerve be stretched by drawing it in a direction away from the cord, the sensory fibers are more dulled than the motor, but if the traction be toward the cord the motor filaments suffer more than the sensory. We should therefore stretch the nerve in different directions for the relief of pain and of spasm. If the stretching be very severe, it may be followed by trophic changes, just as after a lesion of the nerve produced in any other way. Various theories have been adduced as to the mode of action of neurectasy:

the probability is, however, that its benefit results from some obscure change in the nutrition of the nerve, in its separation from adhesions either to neighboring parts such as cicatrices, etc., or to its own sheath, and in many cases undoubtedly to absolute rupture.

Two methods may be adopted. *First, by operation.* The trunk of the nerve is exposed and loosened from the surrounding parts. It is then stretched either by hooking it up by the fingers, or in a small nerve such as the seventh nerve by a common pocket button-hook or similar instrument, or by Horsley's saddle-shaped hooks for the larger nerves. The *second or bloodless method* is applicable only to the great sciatic nerve. The patient is etherized, the leg kept extended at the knee, and the entire lower extremity, being then used as a straight, stiff lever, is carried into marked and forced flexion at the hip. The results of the last method seem to have been very good in a number of cases, but it must be borne in mind that in adults at least there must be considerable rupture of the bellies of the hamstring muscles, and there have been reported two cases of death after this method.

Conditions to which Neurectasy is Applicable.—The largest number of operations of this kind have been done for ataxia, and often with at least temporary benefit; but usually there has been only slight relief, and in many cases none. In spinal disorder of all kinds, such as paralysis, myelitis, paralysis agitans, athetosis, epilepsy, and tetanus, little good has been accomplished. In "tic convulsif," or spasm of the facial muscles, the facial nerve has been stretched in over twenty cases. In a very small number the relief has continued for months, and in Southam's case even for five years, but in most instances relapse has followed. The relief is so great, however, that the patient is generally willing to submit to repeated operations, and the operation is undoubtedly to be recommended. Neurectasy has also been used for wry neck, in a few cases with cure or benefit. Anesthetic leprosy has also been so treated with improvement. In all cases where nerve-stretching has failed to relieve it is possible to do a later neurotomy or neurectomy; hence very often neurectasy should precede these more severe operations.

III. and IV. Neurotomy and Neurectomy.—These two operations of simple section of the nerve and exsection of a portion of it may be considered together, as they differ only in the treatment of the nerve. As a rule, neurectomy is to be preferred to simple neurotomy. They are done occasionally for muscular spasm, but most frequently by far for neuralgia. Either may be done as a primary operation or secondary after neurectasy. Neurotomy can sometimes be done subcutaneously, as, for instance, in the supraorbital or the infraorbital nerve. When several nerves lie close to each other, as in the armpit, and there is doubt as to which is the nerve sought for, faradizing each exposed nerve in turn will differentiate them. Once the nerve is exposed it can be stretched, divided, or a portion of it exsected as may be desired. The following nerves are those most commonly operated on:

1. The **supraorbital nerve** emerges on the face through the supra-orbital foramen or notch. If it is a notch, it can usually be felt, but if a foramen it can also be readily found, as it lies at the junction of the inner and middle thirds of the eyebrow. A simple curvilinear incision one inch in length, which if made in the eyebrow will be hidden by the hair, is sufficient to disclose the nerve.

2. The **Superior Maxillary Division of the Fifth Nerve.**—A line drawn from the supraorbital notch downward between the two lower bicuspid teeth intersects the infraorbital and mental foramina. The infraorbital nerve emerges at the former foramen. Simple section of this nerve, which was

formerly done for neuralgia, has been very properly abandoned. A curved incision an inch and a half long is made just below the lower border of the orbit. Where this incision intersects the line above mentioned the nerve will be found under the levator labii superioris, lying much deeper from the skin than would be supposed. The nerve having been found, a silk thread is passed under it by means of an aneurysm needle, and the thread is tied in order to identify and make traction on the nerve. The upper border of the incision is now raised by a spatula or retractor, and with a grooved director or other instrument the periosteum covering the floor of the orbit is lifted and held up by the spatula. Even if not at once seen, the canal for the nerve is readily found and broken in by pressing on the floor of the orbit with the grooved director. By a small sharply-curved hook the nerve is lifted from its bed and divided far back in the orbit by means of curved scissors. Traction on the anterior end will now pull out the entire nerve. Moderately sharp bleeding usually follows the division of the nerve in the orbit, but is readily arrested by packing with a little gauze. The bleeding of the external wound is controlled by hemostatic forceps.

3. Removal of Meckel's Ganglion.—Sometimes after removal of the superior maxillary division as above described, or better as a primary operation, Meckel's ganglion and the nerve are removed. This is done by Carnochan's method, or better by Chavasse's modification of it. It consists of a T incision below the eye, the horizontal part reaching from canthus to canthus, and the vertical one nearly to the mouth, but without entering this cavity. The infraorbital nerve is found, and as before is tied with a piece of silk. The anterior wall of the antrum is then perforated by a three-quarter-inch trephine or a chisel, including the infraorbital foramen. A half-inch trephine or a chisel is applied to the posterior wall of the antrum, care being taken merely to penetrate through the bone and not to wound the internal maxillary artery, which lies close behind it. The nerve is next divided on the cheek, and, after breaking through its groove in the floor of the orbit, the nerve is drawn down through the trephine opening. By this method the nerve is preserved and utilized as a guide to the ganglion. The nerve, being made tense, is now traced into the spheno-maxillary fossa and to the foramen rotundum, and is divided just below the foramen with long delicate curved scissors. To control the hemorrhage iodoform gauze and small sponges on sponge-holders are best, and it is almost essential that an electric light or forehead mirror be used to illuminate the deep parts of the wound. Abbe has recently recorded two cases in which he removed the nerve by a single horizontal incision one inch and a quarter in length, breaking down both the anterior and posterior walls of the antrum with a simple gouge. After removing the nerve he packed the wound lightly with strips of iodoform gauze, and did not suture it until he removed the gauze, forty-eight hours after the operation. Sensation being paralyzed, no pain is caused by the late sutures.

Instead of trephining through the antrum, Horsley, after exposing the nerve, lifts the contents of the orbit with the periosteum of its floor, lays open the canal by sharp-pointed bone forceps, and then follows the nerve to the foramen rotundum. Often the antrum will not be opened. Luecke resects the zygoma, turns the temporal muscle up, and so gains access to the ganglion.

4. Inferior Dental Nerve.—Several operations have been devised for this, but the best are as follows:

(1) *By External Incision.*—An incision two inches long is made along the lower border of the jaw, beginning slightly behind the angle. This is better than a vertical incision, which is almost certain to divide some branches of the

seventh nerve, and may paralyze the muscles of the mouth. The incision, being well under the border of the jaw, is entirely hidden in men by the beard and partly hidden in women by the jaw. The upper edge is displaced upward on the vertical ramus, and after scraping away the masseter muscle a half-inch trephine is applied an inch and a quarter above the angle. This exposes the nerve at its entrance into the inferior dental foramen. The nerve, having been brought to the surface by a small sharply-curved hook, is first stretched, and then as much of it as possible is excised. If desired, the incision can be prolonged above and parallel to the edge of the jaw, and the canal for the nerve be laid open all the way to the mental foramen. Commonly rather copious hemorrhage is caused by the division of the inferior dental artery if this is involved in the cut. Packing will usually control it, but occasionally a ligature is necessary. By this same incision the nerve may be removed without trephining by separating the parts behind the jaw instead of in front of it, scraping the internal pterygoid muscle instead of the masseter loose from the jaw, and finding by the finger the sharp point of bone which marks the inferior dental foramen. The nerve can now be brought to the surface as before and be stretched and excised.

Horsley has recently proposed a new method by a vertical incision through only the skin and fat, beginning just above the zygoma, extending to the angle of the jaw, and then following its lower border as far as the facial artery. This flap is lifted without cutting the branches of the facial nerve. Between the upper branch of the nerve and Stenson's duct the masseteric fascia is divided, and the opening widened to three centimeters in diameter. The parotid is now retracted toward the ear and the posterior border of the jaw defined. Next the posterior two-thirds of the masseter are divided and the jaw cleaned, so that the sigmoid notch is well seen. By drilling several holes and by a small trephine the bone is removed, so that the sigmoid notch is prolonged downward twelve to fifteen millimeters to the border of the inferior dental foramen. Division of the periosteum on the inner surface of the jaw then discloses the inferior dental nerve. This can be followed to within a centimeter of the foramen ovale and excised. The lingual nerve lies half an inch deeper and somewhat in front of the inferior dental, and may also be excised. The bleeding is free, but controllable. The internal maxillary artery may have to be ligated and divided. An electric light is essential.

(2) The nerve can also be reached *through the mouth*, as follows: The mouth being held open as widely as possible by a gag on the opposite side, the mucous membrane is incised along the anterior border of the ramus of the lower jaw between the last molar teeth of the two jaws. The finger can now be inserted between the internal pterygoid muscle and the ramus of the jaw. The muscle being separated from the bone, the same sharp projection of bone at the opening of the inferior dental foramen before referred to is found and the nerve brought to the surface with a hook. The long internal lateral ligament of the jaw must not be mistaken for the nerve. Hemorrhage was very profuse in two instances on record, and gave considerable trouble.

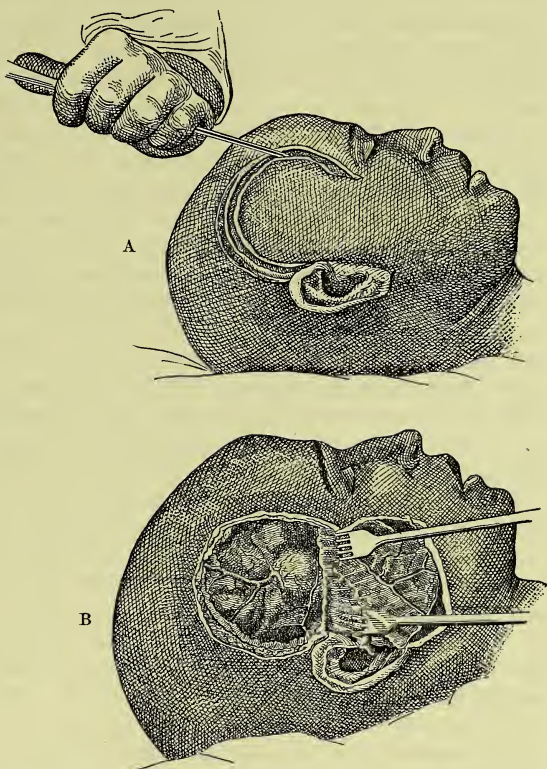
5. **Removal of the Gasserian Ganglion.**—In not a few cases after the above operations, especially on the superior maxillary and inferior dental nerves, the neuralgia returns, and in order to remedy the pain Rose, Andrews, and others have removed the Gasserian ganglion itself. This ganglion lies, it will be remembered, on the anterior surface of the petrous bone underneath the dura, but above a layer of the periosteum which lies between the ganglion and the base of the skull. Mr. Rose's later method is as follows: The eyelids are first sewed together to protect the ball, the sutures being removed on the fourth

day. A curved incision is made from half an inch below the external angular process along the zygoma to its posterior extremity, then downward to the angle of the jaw, and finally along the lower border of the jaw to the facial artery. The flap is then dissected forward without wounding the facial nerve or Stenson's duct. The zygoma is first drilled and then divided, and turned downward with its attached masseter muscle. The coronoid process is similarly divided, and displaced upward with its attached temporal muscle, and later is removed. The internal maxillary artery is then ligated and divided. The external pterygoid muscle is separated from the great wing of the sphenoid and the external pterygoid plate. A long-handled half-inch trephine is next applied a little anterior and external to the foramen ovale, the edge of the trephine just impinging on the edge of the foramen. The trunk of the nerve is used as a guide to the ganglion, which is then removed by small, sharply-curved hooks, one of which has a cutting concave border. Hemorrhage gives considerable trouble. An electric forehead light is essential in working at such a depth. The results of the first case after twenty-two months were entirely favorable so far as the nerve was concerned, but the eye was destroyed and had to be removed—a calamity happily avoided by the improved technique of later cases, all of which, at least so far, have remained free from pain.

Recently, the osteoplastic method of resection of Wagner-Wolff (p. 487) has been applied to this operation. In 1892, Hartley, and a few months later

Krause, published independently identical methods of opening the skull by an osteoplastic resection. The usual horseshoe-shaped incision is made through the scalp directly down to the bone, but the flap is not lifted from the bone. The vertical and horizontal extent of the incision is usually about three inches. The base (Fig. 148) thus marked out is much smaller than the remainder of the flap, and terminates in front of the ear and behind the external angular process of the frontal bone. A groove is then cut in the bone with a chisel, and the inner table entirely divided by an osteotome, after which two or three periosteum elevators are inserted into the groove, and the flap, consisting of bone and scalp together, is lifted to such an extent as to

FIG. 148.



Intracranial Neurectomy of the Fifth Nerve (Hartley): A, manner of holding the chisel in cutting the groove through the bone; B, flap lifted and turned down, exposing the dura mater and middle meningeal artery.

snap the bone on a line between the ends of the incision. The middle meningeal artery is unavoidably torn if it runs through a canal in the anterior inferior angle of the parietal bone, and even if not it is often torn by the small branches passing directly from it into the bone.

The dura is not opened. The temporo-sphenoidal lobe is then lifted from the middle fossa of the skull until the second and third divisions of the nerve are recognized. Just behind their junction lies the ganglion. The nerves are then cut as close as possible to their foramina of exit and the ganglion is broken up, or if possible is removed. In several cases the bleeding on lifting the temporo-sphenoidal lobe has been so profuse as to require packing by iodoform gauze. This has been removed after three days, and the ganglion and nerves then resected. An electric forehead light is almost essential in the operation. Keen has recently collected forty cases, of which six died and thirty-four recovered. Half the cases were done by Rose's and half by the Hartley-Krause operation. Mr. Horsley believes that the entire ganglion cannot be removed without opening the cavernous sinus.

Mixter of Boston has devised an operation for resecting both the second and the third divisions of the nerve at the foramina rotundum et ovale, which has been done several times successfully. He advises a curved incision through the origin of the temporal muscle, beginning and ending over the zygoma, which is sawed through at each end, care being taken not to go back of its tubercle, as the articulation would then be opened. The temporal and pterygoid muscles being separated and turned down with the zygoma, both nerves may be reached at the foramina. This incision was previously described by Salzer as a method of reaching the foramen ovale.

6. The Lingual Nerve.—This has occasionally been operated on for the relief of pain in cancer of the tongue. A suture is passed through the tongue on the side of the operation. Pulling the tongue forcibly toward the opposite side makes the lingual nerve tense, and it can be felt in the floor of the mouth as a firm band beneath the mucous membrane. An incision is made through the mucous membrane and a hook passed under the nerve, which is then stretched or excised. If the tongue is fixed by the growth, the nerve may be exposed where it lies in contact with the lower jaw-bone just under the mucous membrane beneath the first molar teeth.

7. The Seventh Nerve.—One of two methods may be adopted to reach the nerve. First, the *method of Baum*, which is the best, as the nerve is readily found and the scar is hidden by the ear. A vertical incision two and a half inches long is made behind the ear, with a slight angle at the apex of the mastoid. The posterior border of the parotid is the first landmark. Displacing this forward, the shining aponeurosis of the sterno-cleido is the second. Clear the interspace between these two to a depth of one to one and a half inches, when the prevertebral muscles and their fascial covering are the next mark. The nerve lies in front of this fascia, crossing the deep and narrow space between the mastoid and the vertical ramus of the jaw. The electric light and the forehead mirror are very great helps. To find just where the nerve crosses this space, place a moist sponge electrode on the cheek; the nerve will be found by touching the tissues at successive points with a fine wire attached to the other cord of the battery. The current should be very weak.

In *Hüter's method* the vertical incision is made in front of the ear. One of the two main branches of the nerve will be exposed in the parotid gland, and is to be followed back to the main trunk. In this method the trunk of the nerve is apt to be reached in front of the point where it gives off its

branches to the occipito-frontal and the orbicularis, and these branches may escape being operated on.

8. **The Spinal Accessory Nerve.**—This has been operated on especially for wry neck. The nerve pierces the sterno-cleido-mastoid muscle, and then passes to the trapezius, supplying both of these muscles. It may be operated on before or after its passage through the sterno-cleido-mastoid: (A) If operated on before it enters this muscle, the incision is made along the anterior border of the muscle downward from the lobule of the ear for two or three inches. The muscle being exposed and turned outward, the nerve is discovered a little above the level of the hyoid bone where it enters the muscle. (B) To reach the nerve after it has emerged from the sterno-cleido-mastoid muscle the incision is made along the posterior border of the muscle two inches long, the center of the incision corresponding to the center of the muscle vertically. The nerve will be found a little above the center of the wound, and should be traced upward to its point of emergence from the muscle and excised. The former operation is the better one.

9. **Division of the Nerves of the Posterior Cervical Muscles for Wry Neck.**—Keen has described an operation for the excision of the posterior divisions of the first three cervical nerves, which may be done either independently of the operation on the spinal accessory or as an adjunct to it. Noble Smith and Powers have since done similar operations.

10. **Cervical Plexus.**—The branches of the plexus may be reached by means of an incision along the middle of the posterior border of the sterno-cleido-mastoid muscle.

11. **Brachial Plexus.**—The brachial plexus may be readily exposed just above the clavicle by the horizontal incision for the ligation of the subclavian artery. The plexus is reached immediately under the deep fascia. The nerve-trunks are easily recognized, and one or more of them may be operated on as is deemed best. Care is required not to mistake the lowest cord for the artery.

12. **Median Nerve.**—In the arm the median nerve is readily reached by the incision for ligation of the brachial artery, at the inner border of the biceps muscle at its middle. The nerve usually crosses in front of the artery from without inward. In the forearm the nerve can best be reached just above the wrist-joint by an incision two inches long at the inner side of the tendon of the palmaris longus. It lies immediately under the deep fascia. Its branches to the thumb and fingers are easily reached by an incision along the inferior border of the thenar eminence. It lies just under the edge of the palmar fascia.

13. **Ulnar Nerve.**—In the middle of the arm the ulnar nerve can be reached by an incision similar to that for finding the median nerve, but slightly farther back. Behind the elbow it can be exposed by an incision directly over it as it runs in the groove between the internal condyle and the olecranon. A little above the wrist it is exposed by an incision on the radial side of the tendon of the flexor carpi ulnaris. In the two positions first described the nerve lies immediately under the deep fascia. Just above the wrist it lies more deeply under a second layer of the deep fascia.

14. **Musculo-spiral Nerve.**—This can be readily found in the musculo-spiral groove by an incision corresponding to the groove between the biceps and supinator longus muscles. The deep fascia having been divided, the nerve is found in the interspace between these muscles, and can be felt as a cord rolling between the finger-tips.

15. **Radial Nerve.**—This branch of the musculo-spiral can also be easily found by a longitudinal incision on the outer border of the forearm, about three

inches above the wrist-joint, just where the nerve passes under the tendon of the supinator longus to the back of the hand.

16. Great Sciatic Nerve.—The patient should be placed upon his abdomen and an incision about four inches long should be made in the middle line of the leg, beginning just below the gluteo-femoral crease. As soon as the deep fascia is cut through, the belly of the biceps will be found, and on tearing through the connective tissue at its outer border the trunk of the great sciatic will be found with ease.

17. Tibial Nerves.—The anterior and posterior tibial nerves may be exposed by the same operations as for ligation of their respective arteries. The posterior tibial may also be exposed by a curved incision behind the internal malleolus and the heel. It lies just posterior to the artery.

CHAPTER VII.

SURGERY OF JOINTS.

SECTION I.—GENERAL CONSIDERATIONS.

LIKE the other structures of the body, the joints are subject to injury and disease. All the articulations have an anatomical construction which should be kept in mind because of its influence upon the nature and course of the pathological processes that are observed. The more or less expanded ends of the bones, in each of the larger joints, are covered with an incrusting cartilage. They are bound together by a capsular ligament, well developed in the ball-and-socket joints, imperfectly so in the hinge joints, with re-enforcing bands as may be required; such ligamentous structures being firmly attached to the bones and closely connected with the periosteum. The joint-cavity, except over the articulating cartilages, is lined by a synovial membrane, which is either a closed sac or communicates with adjacent bursæ. It is sufficiently lax to permit of the free movement of the bones upon each other, and consequently is more or less folded and fringed, and holds and covers larger or smaller masses of fat, intended to lessen shock. Outside the capsule and supported by connective tissue are the muscles moving the joint, their bellies, or more generally their tendons, often running in well-formed sheaths. These muscles are always innervated by branches of the same nerve that sends filaments to the joint structures proper, and from the same trunk come the fibers distributed to the fasciæ and the skin over the insertions of the muscles. The blood-vessels, each arising from the nearest large trunk, quickly break up into many small branches running among the fibers of the ligaments in the subsynovial connective tissue and in the synovial membrane; the incrusting cartilages being nourished by imbibition.

Inflammations of varying intensity are of frequent occurrence: they may be due to traumatism, to rheumatism or gout, to the presence and chemical products of micro-organisms, or to disturbances of innervation. They may be slight or severe, acute or chronic. They may terminate in resolution, in permanent new formations more or less deforming and disabling, or in destruction of the articulation. They may originate in the joint structures proper, especially in the synovial membrane, or they may extend from contiguous parts, the cancellous bone-ends, the overlying tendon-sheaths, or the periarticular

connective tissues. They may be largely confined to a single structure, the synovial membrane being the part ordinarily affected, or they may involve the whole of the joint.

The usual inflammatory changes in blood-supply, in cell-development, and in function are all present. Vascular fulness is observed chiefly in the acute affections and in the synovial membrane, which becomes reddened, it may be intensely so, especially in its fringes. Effusion of serum takes place in the membrane, in the connective tissue beneath it, in the interspaces of the ligaments, and particularly into the joint-cavity. The endothelial cells proliferate unduly and are thrown off, even to the extent at times of rendering the synovial fluid milky or purulent in appearance. Fibrinous exudations occur on the free surface and in the membrane and capsule. New cell-growth takes place in excessive amount in certain of the inflammations—*e. g.* the tubercular. Extravasations of blood may occur into or beneath the synovial membrane or into the cavity. The articular cartilage may undergo no material change, or may become softened and absorbed under pressure or by the action of the new-formed granulation-cells, or be separated in large flakes, or undergo atrophy, or become hypertrophied around its edge. The ligaments also may be essentially unaffected, or they may split up and degenerate in part or wholly, their place being taken by a lardaceous new formation. In all cases function is impaired, either as a whole with reference to movement or as respects the synovial membrane and its secretion of synovia, which latter may become very abundant and very watery, or very scant, not enough to lubricate the surfaces, which grate as they rub against each other.

SECTION II.—SYNOVITIS.

Except in acute attacks, mainly due to injury, an inflammation lighted up in the synovial membrane does not remain confined to it, but affects the other parts of the joint, and is an *arthritis* and not a *synovitis*, although not seldom even in very chronic cases the synovial affection is the chief one.

As the result of an aseptic wound, of a subcutaneous injury (contusion or sprain), of the irritation produced by a floating cartilage, or of exposure to cold and dampness, simple inflammation may attack the synovial membrane. The part becomes congested, chiefly around the edges of the cartilage and in the fringes, which because of their undue vascularity and the associated oedema are somewhat elongated. At times the whole membrane is highly injected and oedematous. The synovial secretion is more or less increased in amount according to the nature and intensity of the inflammation. In character it may remain normal or may become watery. Because of existing fibrinous exudations it may be flocculent.

The **symptoms** are unmistakable. The joint is painful, especially upon motion, often severely so, and particularly at night. It is swollen and tense, it may be fluctuating. At the knee the patella is floated up from the condyles, upon which it can readily be depressed, to rise again when pressure is taken off. By the muscular contraction of the flexors the joint is held in that position which permits of greatest distention and is therefore the most comfortable. The part is never in full extension, the production of which much increases the suffering. Each joint has its position of greatest ease, which is spontaneously and quickly assumed when inflammation occurs. The swelling is most marked in the spaces between the ligaments and where the capsule is not crossed by firm tendons. The local heat is decidedly raised, but the skin, while it is very sensitive to pressure, perhaps only at certain points, is neither

thickened nor reddened. Constitutional symptoms if present are only moderate in degree. After a few hours, or at most days, the intensity of the symptoms subsides, the pain lessens, the swelling diminishes as the effusion and extravasated blood are absorbed, the limb takes its natural position, and recovery quickly follows. If there has been much hemorrhage into the cavity, there may be afterward some restriction of motion in consequence of organization of a part of the clot and its adhesion to adjacent sides of the folded synovial membrane.

In the **treatment** the joint should be placed at rest. Cold may be locally applied by an ice-bag or a coil of rubber tubing (Leiter) or by continuous irrigation; or hot applications may be made, simple or medicated, the lead-and-opium lotion being perhaps the best; or equable pressure as firm as can be comfortably borne may be employed, the affected region being enveloped in a thick layer of cotton or wool, and a bandage, preferably of rubber, put on. The cotton or wool next the skin may be moistened with the hot lead-and-opium wash, and the advantages of both heat and pressure be secured; or the joint may be at once immobilized in plaster of Paris. Pressure will ordinarily prove most satisfactory. Unless the serous distention of the joint is extreme or there has been a large extravasation of blood into the cavity, the fluid will not need to be drawn off, but may be left to the action of the absorbents. If aspiration is done, every precaution must be taken to prevent sepsis.

Chronic Synovitis.—As already stated, a synovial inflammation, whatever its intensity, cannot long continue without extension of the morbid process to other structures of the joint and the development of an arthritis; yet not seldom the affection of the synovial membrane, so far as disturbance of its function is concerned, remains so prominent a clinical feature that the case may be very properly viewed as one of chronic synovitis. The active congestion that belongs to the acute stage, of which the chronic is usually the sequence, largely disappears, leaving the membrane but little changed in appearance from the normal. There is, however, an undue amount of fluid in the cavity, and the membrane itself is cedematous. Later, if the disease does not subside, the membrane and the articular structures become irregularly thickened by plastic exudation and the formation of fibrous tissue, with intervening patches where there have been degeneration and softening. The folds of the membrane are not seldom fastened together by adhesions resulting from the organization of blood-clots or from an exudation thrown out between them; and at times from the fringes and villi there are developed, it may be in great number, growths larger or smaller, often pedunculated, that push into the cavity. There is little or no change in the temperature of the part. Though the joint is weak, it is not specially painful except upon pressure, and may not be so even then. Movements, especially in extension, are restricted, and generally, as the effused fluid has become absorbed, are attended by some grating or creaking. It is the presence of an undue, often an excessive, amount of fluid in the joint that is alone to be here considered, all the other conditions being those of long-standing arthritis dependent upon diathetic, suppurative, or infective causes. The symptoms of such accumulation of fluid are well marked. The joint if a superficial one (and it is the knee that is by far the most frequently affected) is evidently distended, perhaps very much so. There is fluctuation upon palpation. The muscles in the vicinity are wasted, it may be considerably, making the articular enlargement the more prominent. With the hypodermatic needle fluid may be drawn off which will ordinarily be straw-colored or a little darker, somewhat viscid, occasionally flocculent, and at times more or less blood-stained.

The **treatment** varies with the amount of fluid present and according

to the type of the arthritis; for it must be remembered that superabundance of fluid in a joint is not in itself a disease, but a symptom of a traumatic, a rheumatic, a tubercular, or a deforming arthritis, or even of some local or general disturbance of the circulation. When the affection is not of long standing and the articular fulness is not very great, rest and pressure may be all that will be required to produce absorption, the joint being enveloped in cotton and bandaged (the elastic bandage being the best) or preferably immobilized with plaster of Paris. Baths, frictions, massage, electricity, blisters, mercurial ointment or plaster, each has often been found of service. Simple aspiration followed by immobilization may bring about recovery, or if, as is apt to be the case, reaccumulation of fluid takes place, it will be in much diminished quantity and will very likely be readily absorbed. When the affection is of long standing and the joint is much distended, with associated marked impairment of its usefulness, in the condition which may properly be called *hydrarthrosis* or *hydrops articuli*, when the methods of treatment already spoken of have been thoroughly tried and have proved useless, very excellent results may be secured by aspiration and injection of a 3 per cent. to 5 per cent. solution of carbolic acid. The parts having been thoroughly disinfected, the fluid is aspirated (every care being taken to have the needle aseptic), the cavity is irrigated with freshly boiled water until the fluid comes out perfectly clear, and then the 3 per cent. or, better, 5 per cent. carbolic solution is injected, after which the joint is immobilized. This method of treatment should not be adopted so long as there is any inflammation in the joint, and the operation must be done with the most scrupulous precautions as to asepsis.

SECTION III.—ARTHRITIS.

Inflammation of a joint as a whole may be either acute or chronic. It may be consequent upon the presence of pyogenic cocci, of infection by the bacilli of tuberculosis, or of the micro-organisms of any one of the acute infectious diseases, or of gonorrhea; upon rheumatism or gout or the rheumatoid condition, whatever may be its nature; upon syphilis; and upon lesions of the nervous system, especially tabes.

(A) **Tubercular Arthritis.**—The great majority of cases of chronic joint disease are tubercular, the bacilli being primarily deposited in the bone, the synovial membrane, or the capsule and periarticular structures; most frequently, especially in children, in the bone. In this osseous variety of joint tuberculosis the secondary infection of the soft parts takes place after destruction of the cartilage over a carious area or over a wedge-shaped tubercular infarct in the epiphysis, with resulting opening of the joint-cavity; or through a sinus extending to the synovial membrane outside the cartilage or reaching the capsule farther out; or, which is of comparatively rare occurrence, from the tubercular periarticular structures, the ligaments and the synovial membrane becoming infected by the extension of the morbid process. When the synovial membrane is affected, whether primarily or secondarily from a neighboring focus in the bone it matters not, the developed granulation-tissue is usually abundant and soon extends to and involves the capsule and the structures outside of it. The parts become thickened, œdematous, and of a gelatinous or lardaceous appearance, little or no fluid being present in the synovial sac. Occasionally the membrane is thickly studded with small tubercles, and is highly vascular; there is little new formation of tissue, but an abundant serous effusion into the joint takes place. In other cases the inflammation is a plastic one, the outgrowths being few and large or papillomatous and very numerous. In the ordinary

fungous variety (the "gelatiniform" or "gelatinoid degeneration" of many writers), as the result of the new growth and the oedematous infiltration, a marked change soon takes place in the size, shape, and appearance of the articulation. The natural elevations and depressions disappear, the softened ligaments offering little or no resistance to the pressure of the growing granulation-masses, with which before long they become incorporated.

The contour of the joint is globular or, more properly, spindle-shaped, because of the decided atrophy of the parts above and below and the swelling of the periarticular structures. The skin, as the result of obliteration of the vessels and oedematous infiltration, is white, thick, and firmly attached to the fascia beneath. A few large superficial veins can generally be seen. Palpation may and often does develop pseudo-fluctuation, because of the abundance of fluid in the tissues, and true fluctuation in the exceptional cases in which there is a large serous accumulation in the synovial sac or when the joint is distended with the so-called tubercular pus, which is not pus, but the milky fluid of the liquefying caseated masses. Pain is, as a rule, but slight in the strictly synovial variety; in the osteal form it is decided, and may be very severe. It is always to be elicited by pressure, although perhaps only over a limited space. When the originally synovial disease has extended to the adjacent epiphysis, pain will be present, even if previously absent. The heat of the part is always increased, but often the elevation of temperature is so slight as to be detected only by careful use of the thermometer.

Deformity is a constant accompaniment of the disease; its degree is greater or less according to the joint affected, the amount of disease present, and the treatment pursued. It is due to (1) the natural tendency of the parts to take the position of greatest ease; (2) the softening and destruction of the ligaments; (3) muscular contractions induced by reflex irritations. These causes often result in permanent vicious attitudes, assumed and maintained by the patient through a long period of time.

Caseation and liquefaction of the fungous masses take place here as elsewhere, giving, it may be, no evidence of their occurrence when the disease is of limited extent, but indicated generally by the formation of so-called abscesses and sinuses. The opening of these sinuses is almost certain to lead to pyogenic infection unless the latter is prevented by antiseptic treatment. When it occurs it results in a marked aggravation of the general and local morbid state. Very frequently in the history of a tuberculous joint, extending over months or years, a number of openings will successively arise, the sinuses which communicate with these limited degenerations of fungous masses, carious patches, or sequestra of small size alternately opening and closing.

The diagnosis of joint tuberculosis is easy, difficult, or impossible according to the extent, the character, the location, and the duration of the affection. If of the fungous variety in a superficial joint, advanced to the stage of decided deformity, still more to that of abscess and sinus, there can ordinarily be no mistaking the nature of the trouble. Syphilitic disease has points in common, but it is of comparatively infrequent occurrence, and generally there will be in the history of the individual or in the condition of other parts of the body evidences of a pre-existing specific infection. But if the disease is osteal, has advanced but little, has caused only a slight impairment of the articular motions, hardly, it may be, more than an unwillingness fully to use the joint, is attended with little pain and no appreciable swelling or atrophy, if the muscular rigidity is so little as to make it doubtful whether it exists, and if finally the joint is a deep one, the disease very likely will be overlooked. At best the diagnosis is but a probable one. In all such cases, even when there is only a well-grounded suspicion

of the existence of tubercular disease, the patient should be given the benefit of the doubt and treated for a time as though the disease was unquestionably present.

What is called "pannous synovitis" is rarely met with. In this form the tubercles are small and in great number, the vascularity of the membrane intense, new formation of very limited extent, and the ligaments and periarticular structures but slightly affected. The great serous accumulation in the synovial sac will almost certainly be regarded as non-tubercular in character until after aspiration and examination of the fluid.

The **prognosis** depends upon the extent of the disease, the general condition of the patient, and especially upon the treatment employed. In a few cases, doubtless, the tubercular area is so small, the extension of the morbid process so easily arrested, the new formation so slight, and the adhesions and bands developed in its cicatrization so limited, that after recovery has taken place there will be little, it may be practically no impairment of the motions of the joint. But in the great majority of cases this does not occur. The cartilages are more or less extensively destroyed, intra- and extra-synovial bands are formed, and the size of the joint-cavity is diminished. In proportion as there has been damage to the component structures of the articulation must the functional value of the joint be lessened, all the more when there has been displacement of one bone upon the other. The restriction of motion may be absolute. Ossification of the granulation-tissue uniting the surfaces of the epiphyses, which have been deprived of cartilage and eroded by caries, may have taken place (true bony ankylosis), progressing sometimes to the extent of complete fusion of the two bones; or the same result may have been secured without ossification, short, firm fibrous bands existing within the capsule, the action of which is further reinforced by ligamentous and periarticular contractions and adhesions (false, fibrous ankylosis). At times, though recovery has been in a great measure secured, a sinus or sinuses will long remain because of the presence of a limited amount of carious or necrosed bone or of the tuberculation of the sinus wall. Even where all morbid action seems to have been arrested, and the patient for months, it may be for years, has been free from all indications of disease, the joint may again become the seat of tubercular inflammation, either because of the setting free of primarily encapsulated organisms or because as a place of least resistance it most readily becomes the field of a new infection. During the necessarily long period that must elapse before recovery can take place there is an ever-existing danger of the development of visceral or general tuberculosis. Caseation, if extensive, is associated with constitutional disturbances of greater or less severity. When sinuses have opened, septic infection of the diseased parts is almost certain to occur unless prevented by antiseptic treatment, and the resulting suppuration exposes the patient to the added risks of exhaustion, amyloid disease, and septicemia.

The **treatment** is that of tubercular disease in general. The indications are to prevent, or, as far as possible, to limit, the multiplication of the bacilli and the extension of their action; to favor the condensation and cicatrization of the non-tubercular new-formed granulation-tissue; failing in this, to remove the infected part. For the fulfilment of the first, *rest* is of the utmost importance, since it lessens irritation and diminishes the blood-supply and the rapidity of its flow. It may be secured by splints and muslin or rubber bandages, but best by immobilization. The joint having been enveloped in a thick layer of cotton, the plaster-of-Paris bandage is to be firmly but not too tightly applied (that the beneficial effects of pressure may also be secured), not only over the joint, but also nearly to the levels of the joint above and that below, care

being taken that the joint is held in a position of ease during the setting. Such immobilization must be continued for weeks, often for months, new bandages being applied as the size of the joint diminishes. If this is employed at an early period and the affected limb is kept quiet, recovery may be expected in a large proportion of cases of joint tuberculosis. Instead of the plaster-of-Paris bandage, a fixation or a traction-and-fixation splint may be employed, and is by many regarded as preferable, but in general the plaster bandage will be found to secure more complete rest of the joint. Accumulations of fluid, either intra- or extra-articular, may very properly be removed by aspiration, provided a thoroughly aseptic needle is used, but in the ordinary cold abscesses consequent upon joint inflammation if the disease is thoroughly treated the abscesses may safely be left to take care of themselves. If they are tapped they should also be well irrigated, preferably with an oil or glycerin solution of iodoform (5 to 25 per cent. of the former; 5, or better 10, per cent. of the latter). For the relief of pain and localized tenderness ignipuncture or penetration into the bone with the thermo-cautery has been used with advantage.

When the case is one of tubercular dropsy, aspiration should always precede the application of the immobilizing dressing, or, better, aspiration followed by the iodoform injection.

Much attention has of late been given to the discovery and employment of agents that will condense and favor the cicatrization of the new tissue outside of the tubercular area and bring about the destruction or encapsulation of the bacilli. Chloride of zinc and iodoform are the remedies most in favor. They are injected into and around the tubercular masses, and their employment has certainly proved of service. In using the zinc solution only a few drops are thrown in—three to five drops ordinarily, at times as high as twenty. The tendency seems to be, of late, to increase both amount and strength. The 10 per cent. solution of iodoform in glycerin or oil has been much more largely used, and unquestionably it does both destroy the organisms and favor the condensation of the new tissue. It may be injected once a week or once a fortnight, and continued until the case is evidently well advanced toward recovery or until it becomes certain that no good is being accomplished. This can usually be determined in the course of a month. When used in the treatment of abscesses or of joints containing much fluid the injection should always be preceded by thorough irrigation with freshly-boiled water or a boric-acid solution (3 to 5 per cent.). Instead of either of the remedies mentioned the balsam of Peru may be used to advantage.

Of course, whatever local treatment is adopted, care must be taken to secure for the patient as far as possible those general hygienic conditions which are so strongly demanded by the subjects of tubercular disease, no matter where located; and the ordinary constitutional remedies should be employed.

When the extent of the disease and the local and general effects produced by it are such as to make it certain, or at least probable, that recovery cannot take place under the treatment indicated, or, if it may, that it will be only at great risk to life or after a long time, and then with a limb far from serviceable, conservative treatment must give place to operative. The tubercular tissue must be thoroughly removed, by erosion, by excision, or by amputation. These operations and the indications for the adoption of one rather than another are treated of elsewhere (see Operations on Joints), and need not be considered here.

TUBERCULAR DISEASE OF SPECIAL JOINTS.

HIP-JOINT DISEASE.—Hip-joint disease (*morbus coxarius, morbus coxae*) is very much more common in children than in adults. In the former at least

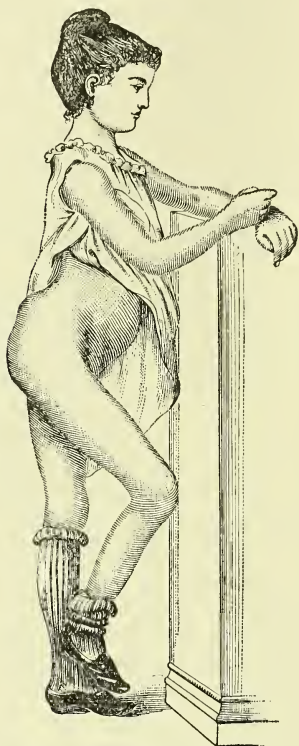
it is generally bony in origin, the tubercular deposit being in the majority of cases at first in the femoral epiphysis, a region naturally subject to the action of repeated shocks and slight traumatism. In not a few patients the acetabulum is first affected, and primary infection of the soft structures of the articulation is probably by no means so infrequent, even in early life, as is often supposed. Whether in the beginning osteal or synovial, the disease naturally presents *three stages*: first, that of deposition of the bacilli and the early irritations and new formations consequent thereupon; second, that of fully-developed arthritis, with its effusions and fungous masses; third, that of breaking down of the infected tissues and greater or less disorganization of the joint, followed by repair, which is usually slowly effected and far from perfect, or by death. Each stage has its distinguishing **symptoms**. Because of the most apparent symptom, the second is often spoken of as the *stage of lengthening*, the third as that of *shortening*.

In the **first stage** the disease is very apt to be overlooked or misunderstood for a considerable time, because of the doubtful or slight character of the symptoms, though occasionally it is indicated at the very outset by well-marked signs. Slight lameness, generally little more than stiffness, is noticed at times—as a rule in the morning rather than later in the day after considerable exercise has been taken. The child is more or less indisposed to play, and quickly tires. Rigidity of the muscles about the joint, especially of the adductors, though not very decided, may be discovered on palpation. The muscles of the thigh are a little atrophied. If the disease is primarily synovial, slight fulness will perhaps be observed over the joint, in front or behind the trochanter, or be recognized on pressure. At times, almost wholly in the osteal variety, pain is complained of, about the hip, in the thigh, or most frequently at the knee, but usually the patient suffers but little. It is not until the epiphysis has become extensively diseased, especially on the side of the incrusting cartilage, that pain becomes a symptom of importance.

In the **second stage** the disease has progressed so far that the symptoms are decisive. The child limps, unquestionably; the atrophy of the thigh is positive, it may be great; the adductor rigidity is marked. If, as is probable, effusion has taken place into the joint, the fulness can be felt, if not seen, and the hip will be evidently broadened sidewise. The affected extremity is advanced and more or less abducted and everted, due to tilting of the pelvis, the weight of the body in standing and walking being thrown on the sound side (Figs. 149, 150). Occasionally, though rarely, the limb is adducted. The gluteo-femoral crease is more or less lowered and shortened, and the lines of the sulcus between the nates and, in girls, that of the vulva, are inclined. The limb is apparently lengthened, but only apparently. Pain will be present sooner or later. It will be located usually in the anterior and lower part of the thigh and the antero-internal surface of the knee in the course of the obturator nerve. It is often “starting” in character, and most severe at night or felt only at that time. But pain of itself is an unreliable symptom, and its absence should never be regarded when other indications of joint disease are present. The hip movements are restricted, chiefly, as a rule, in full extension and abduction. These symptoms are due to various causes: the muscular tension and distant pain, to reflex nervous irritation; the position of the limb, to involuntary muscular action, and, in a measure perhaps, to distention of the joint when effusion has taken place; the starting pains, to sudden forcing of the articular surfaces together. These pains occur chiefly at night, when the protecting muscles about the joint are less under control, and generally indicate more or less extensive destruction of the articular cartilage. The effusion within the joint is slight in the osteal

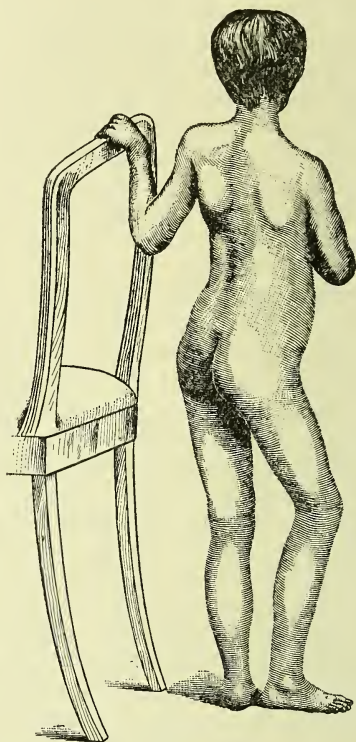
variety of the disease so long as it is simply osteal, but is usually considerable when the soft structures are affected, whether such affection be primary or sec-

FIG. 149.



Position in Coxalgia (Albert).

FIG. 150.



Position in Coxalgia (Albert).

ondary. Not seldom it becomes very great, and causes marked swelling in front of the trochanter major, and still more behind it. Because of the resulting intra-articular pressure the pain is likely to be severe, and the malposition of the extremity in flexion and abduction with seeming elongation to be much increased.

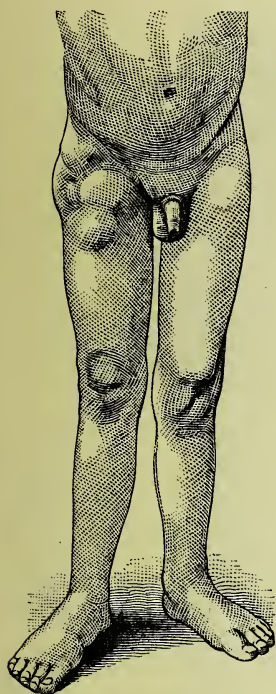
The constitutional symptoms are often severe.

Even when large in amount the effusion may spontaneously disappear to a greater or lesser extent, but not seldom the pressure upon the weakened diseased capsule is so great that rupture occurs, and the fluid is poured out into the periarticular tissues, which it tuberculizes. Abscesses and sinuses will probably follow (Fig. 151). Both local and constitutional symptoms are, as a rule, for a time much lessened in severity as soon as the tension is relieved. As the intra-articular fluid disappears, by absorption or after rupture, the joint surfaces come in contact. The irritated muscles act more directly upon the already damaged head and perhaps the acetabular rim, the bony parts are crowded together and more or less rapidly broken down and worn away, and progressively increasing flexion, abduction, and shortening result, sometimes very rapidly.

The so-called *third stage* is now thoroughly established. The femoral head is often much deformed, and is progressively pushed upward and outward as erosion of the acetabular rim takes place. Actual luxation rarely occurs, the head ordinarily remaining within the capsule, which attaches

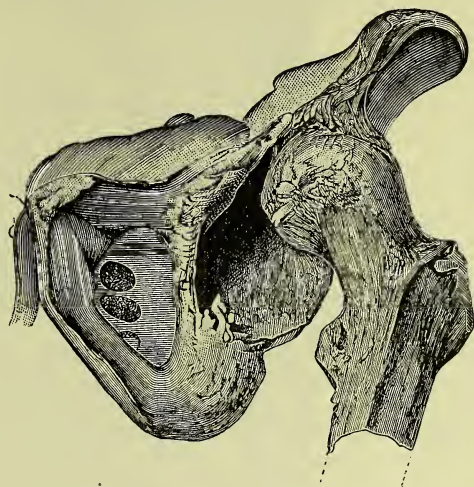
itself farther and farther out on the bone (Fig. 152). The flexion of the thigh upon the pelvis, which has been present in greater or lesser degree from the very commencement of the disease, is now decided and fixed. When the limb is brought down in extension so that the posterior surface of the thigh and that of the knee rests upon the bed or table, the lumbar spine is carried forward, and a marked lumbar curve is at once developed, which disappears as soon as the knee is raised. To determine this point, which is one of great

FIG. 151.



Common Site of Hip Abscess
(Bradford and Lovett).

FIG. 152.



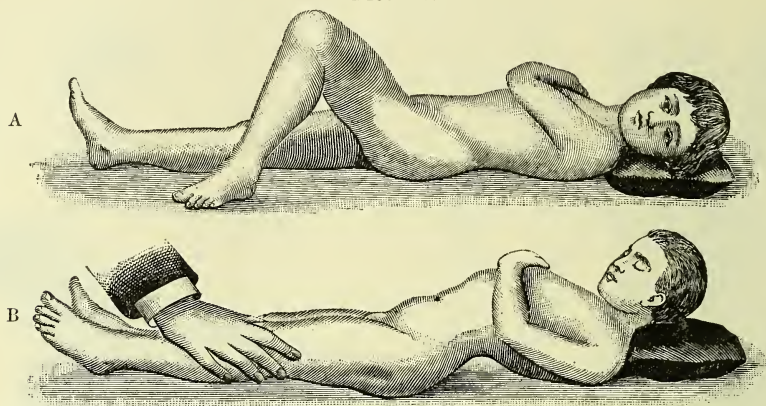
Intra-acetabular Luxation in Coxalgia (Tillmanns).

importance, the patient should be stripped and laid on the floor or a firm table. The *sound* leg can be flexed and extended at both the knee and the hip without any influence upon the lumbar spine (Fig. 153, A). But when the *diseased* leg is extended the lumbar curve becomes so marked that there is often space for the arm of the surgeon to be thrust under it (B). Flexion of this leg and hip is followed by the disappearance of the curve. The reason for this is that the femur and pelvis are held so rigidly together by the muscles that they move as if ankylosed, and the tilting of the pelvis in the extension of the thigh necessarily produces the lumbar curve. The adduction of the limb which in this stage succeeds to the abduction of the second stage is commonly not very great. As the result, however, of neglect of treatment it may reach an excessive degree, the thigh in such cases being usually very strongly flexed and carried across that of the sound side. The whole extremity, including the gluteal region, is greatly atrophied.

When the so-called abscess has opened or been opened, secondary septic infection is almost certain to take place unless prevented by antiseptic treatment. At times, though rarely, when there has been no perforation of the skin, the pyogenic cocci find access to the part by the blood-stream. Upon the occurrence of such mixed infection the parts suppurate, with more or less increase of local heat and tenderness and manifestation of the general symptoms of the "hectic" state. The later symptoms vary greatly according as the case progresses favorably or otherwise. When recovery takes place, the discharge,

if there has been any, lessens, the sinuses, or at least some of them, close, the patient is wholly or in a great measure free from pain, and the general health

FIG. 153.



Effects on the Lumbar Spine of Flexing and Extending the Diseased Leg in Hip Disease (Albert).

improves. Partial or complete ankylosis of the joint takes place, and is either fibrous or bony. In time the weight of the body can be borne on the limb with comfort, the inevitable shortening being made good by a thick sole or a raised shoe. When, on the other hand, the case does badly, new abscesses and sinuses form, the discharge increases, the deformity becomes greater and greater, the constitutional symptoms are graver, and there are very likely clear indications of the existence of visceral tuberculosis or of amyloid disease.

The **prognosis** depends largely upon the treatment. If the disease is recognized early and properly treated, recovery will generally follow in children, though it is a well-established fact that a majority of the patients are likely to die from some form of visceral tuberculosis before reaching full maturity. In adults the chances of recovery are decidedly less. The disease may be arrested at any point in its course, and the earlier this is effected the more nearly perfect will be the recovery. The three stages, it should be remembered, are not always regularly passed through; and if they are, the transition from one to the other may be either slow or very abrupt. From the nature of the cause the disease must be one of long duration, and at whatever point it is arrested, recovery will often be apparent rather than real, and will be followed by relapses, it may be, after many years. The future usefulness of the limb will be in proportion to the adhesions that have formed and the amount of damage done to the articulation. Even in the third stage, if favored by fair hygienic surroundings and a tolerably good state of health, under proper treatment, local and general, the patient, especially if a child, may be expected to recover, though only after months or even years, and with a hip ankylosed at a more or less vicious angle and a limb decidedly and, it may be, greatly shortened. The ankylosis may be fibrous or bony or mixed. In a comparatively small number of cases, after long-protracted disease, the fusion of the femur and the innominate bone is so complete that it is impossible even upon section to determine exactly the line of union. Fig. 154 shows a case of ankylosis of both hips at such an angle that the patient could not stand erect.

As respects **treatment**, the earlier it is instituted the sooner and more perfectly may the patient be expected to recover. The prime indication is to secure *rest*, as absolute as possible, of the diseased part. When the disease is

recognized early, in the great majority of cases prolonged recumbency, especially if combined with extension by weight and pulley, will arrest its progress. A

FIG. 154.



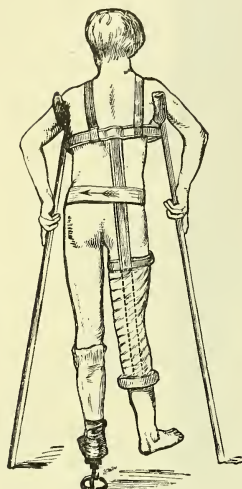
Double Ankylosis from Hip-joint Disease (original).

very simple yet efficient apparatus for securing the desired rest is the gas-pipe frame of Bradford (made of $\frac{1}{4}$ in. gas-pipe joined at the four corners by "shoulders"), which serves at once as a stretcher upon which the patient may be carried and a fixed frame to which a fixation or traction apparatus may be attached. Care must always be taken to make the extension in the line of the deformity; that is, in the line of the flexed and abducted or adducted thigh, which is to be lowered and the abduction or adduction corrected as the progress of the case may permit.

All the varieties of mechanical treatment that have been used—and they are many—have for their immediate object the securing of fixation or traction or a combination of the two. In the first class are to be placed the plaster-of-Paris dressing, the wire cuirass of Bonnet, the "plaster breeches" of Sayre, the leather splint of Vance, the long splint of Thomas, etc. Thomas's splint (Fig. 155), without doubt the most useful of the fixation appliances, is, in brief, a bar of malleable iron about $\frac{3}{4}$ in. wide, extending from the inferior angle of the scapula to the lower third of the leg, so shaped as to accommodate itself to the curve of the buttock, and held in position by three hoop-iron bands, the upper encircling three-fourths of the chest, the second two-thirds of the thigh on a level an inch or two below the perineum, and the third two-thirds of the calf. The apparatus is held in place by bandages and straps, and if the patient is going about, the sound foot is raised by a patten

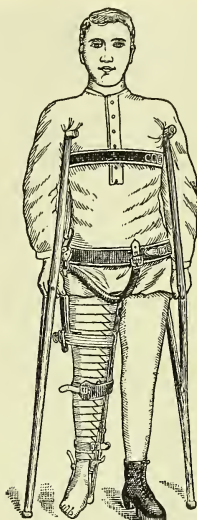
to a height which prevents the toes of the foot of the diseased side touching the ground, and compels the use of two crutches in walking (Fig. 155).

FIG. 155.



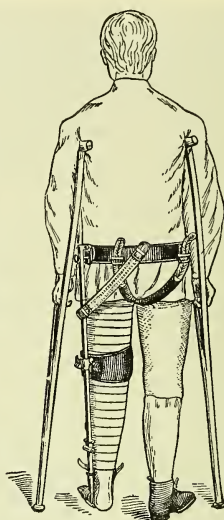
Thomas's Splint.

FIG. 156.



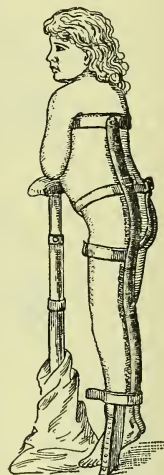
Phelps's Splint.

FIG. 157.



Taylor's Splint.

FIG. 158.



Lovett's Splint.

Recognizing the fact that fixation cannot be absolute, and that it does not overcome muscular contraction with the resulting injurious pressure between the head of the femur and the acetabulum, the great majority of American surgeons are employing some form or other of traction splint, a more or less extensive modification of the Davis splint of forty years ago, early improved upon by Sayre and Taylor. In these splints opportunity is afforded for altering their length at will by drawing away the sliding lower rod of the apparatus from the upper, or by acting upon the foot-piece through the aid of a windlass, the counter-force through the perineal bands preventing the body from following (Fig. 157). Pressure-symptoms are thus prevented or relieved and recovery correspondingly promoted. When by the use of one of these splints fixation is not sufficiently secured (which is comparatively seldom), a combined traction and fixation splint may be employed, many useful forms of which have been devised, among them those of Phelps and Lovett (Figs. 156, 158).

General treatment, if called for by an enfeebled and tubercular state, is indicated, but local medicinal treatment is of no value, except that which will secure the destruction of the bacilli and the condensation and cicatrization of the newly-formed granulation-masses, such as the injection into and around the joint of iodoform, chloride of zinc, or acid phosphate of lime. When the capsule is much distended or there is large extra-articular accumulation, aspiration of the fluid will give great relief. In a few cases the bone has been tunnelled through the trochanter and neck and a permanent drain established. When the so-called abscess is nearing the surface, whether it shall be opened or be left to itself to undergo absorption, as many times happens, or be spontaneously emptied, will depend upon whether or not it is causing much local distress. If it is, it should be aseptically opened and drained, the after-use of iodoform injections being of much service. If it is not, careful attention to the maintenance of quietude is all that will be necessary. If spontaneous opening is imminent, it is

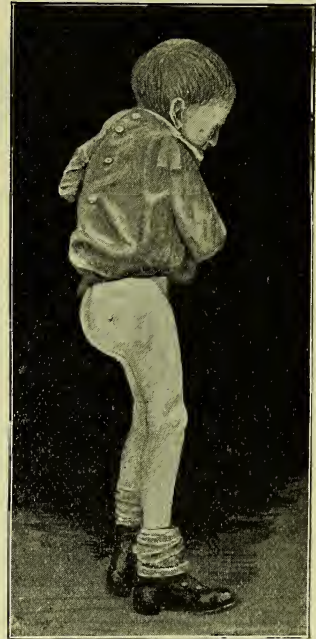
better to anticipate it by incision, as the danger of infection by pyogenic organisms will be thus done away with or reduced to a minimum. In the more severe cases, when the tuberculosis of the bone and joint is extensive, excision or erosion may be done, either early by choice or late from necessity, that which is done early giving, of course, the best result. Though such operative interference, because of its aseptic or antiseptic character, is now not attended with much danger to life, and may be expected to lessen decidedly the period of treatment, yet it does not materially diminish the liability to the occurrence of other or general tubercular disease; recovery is almost always with considerable shortening, and the functional value of the extremity is often no better than that after spontaneous cure, and at times not so good. The resulting deformity can, if necessary, be well and easily corrected by osteotomy through the neck of the femur, or better below the lesser trochanter (Fig. 159).

Fortunately, if the case is seen early and properly treated, the necessity of deciding the question whether or not operation shall be done will seldom arise, and excision is called for much less frequently now than it was a generation ago. When performed, a splint or some protecting apparatus should be worn for a long time afterward until the parts have become firm. Many if not most of the early relapses are due to neglect of such mechanical after-treatment.

KNEE-JOINT DISEASE.—Of the larger joints, the knee, next to the hip, is the one most frequently affected with tubercular disease. In children the disease is as a rule primarily osteal, beginning in the femur oftener than in the tibia, very rarely in the patella. In adults, however, in more than half the cases it shows itself first in the soft parts. The arthritis is so generally and so typically fungous that the term "white swelling," used without qualification, is always understood to mean tubercular disease of the knee.

The **symptoms** in the osteal form are at first ill defined. There is usually slight lameness, with pain in the region of the affected epiphysis, more severe at night, but often only tenderness on pressure, generally over a limited space—by preference the internal condyle of the femur. Later there is expansion of the condyles. The tendons about the joint are somewhat tense, and there is some atrophy, especially of the parts just above the joint on the anterior surface of the thigh. Attempts fully to extend the leg are resisted and cause pain. As soon as synovial inflammation has been set up, the resulting effusion produces fulness of the joint, most noticeable on the sides of the patella and of its ligament. When this is infected by extension from the epiphysis or by primary location of the bacilli in the soft structures in the joint itself, the symptoms become more marked, and soon unmistakable. There are rigidity and atrophy of the part, and lameness, but in many cases this is accompanied with so little pain that the patient continues for a long time to run about. The leg is decidedly flexed, and the flexion steadily increases. But especially and characteristically there is swelling, the firm spindle-shaped enlargement of fun-

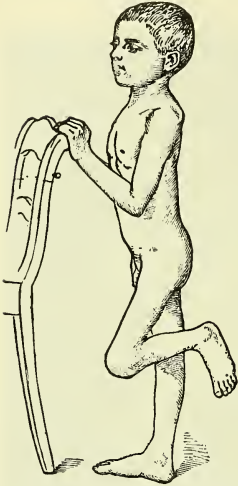
FIG. 159.



Result after Double Subcutaneous Osteotomy of the Femur in the Case in Fig. 154 (original).

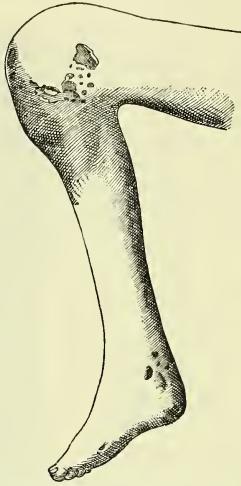
gous disease, in which the natural contour of the joint is lost and the skin over it is pale. Because of this swelling the disease is not likely to be mistaken for anything else, at least in children, though in adults osteo-sarcoma has not so very rarely been regarded as tubercular disease. This error of diagnosis should not occur, certainly if the case has been seen from an early day, since the malignant affection at first and often for a long time causes enlargement not of

FIG. 160.



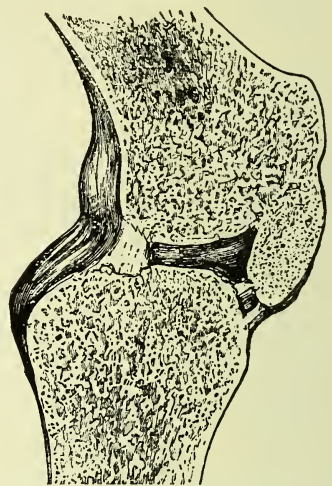
Ankylosis and Contractures in Tuberculosis of the Knee-joint (Tillmanns).

FIG. 161.



Subluxation in Knee-joint Disease (Schreiber).

FIG. 162.



Ankylosis of Knee-joint, partly Fibrous and partly Osseous: the tibia has undergone displacement backward (Marsh).

the joint, but of the parts just above or below it. Caseation and liquefaction of the tubercular tissue give rise to so-called abscesses, which in time undergo absorption, or, more often, open spontaneously or are opened by the surgeon. Through the resulting sinus diseased bone may frequently but not always be felt. Not seldom the leg is drawn back to and beyond a right angle (Fig. 160), and pathological luxation is often produced in badly-treated cases (Figs. 161, 162), after which, as a rule, the severity of the symptoms markedly diminishes. Such a luxation may occur also in spite of treatment.

According to its intensity, and still more to the thoroughness of early treatment, the disease terminates in one or other of three ways: (1) There may be recovery, with more or less deformity and impairment of function, secured after a few weeks or more often months, or, not uncommonly, only after years of discharge, with the elimination of dead tissues both hard and soft, and the destruction of the articulation. (2) Disorganization follows either slowly or rapidly, and if extensive and accompanied with grave constitutional symptoms may compel operation, followed by recovery, which may be speedy or slow, complete or partial. In the latter case sinuses remain, which will continue to discharge for a long time or even for the rest of life. (3) The patient dies from exhaustion, from tuberculosis of other parts, from amyloid disease, or from septic infection, whether an operation has or has not been done. When the case is recognized early and properly treated for a sufficient length of time, recovery with a useful limb may be expected.

The treatment is that of joint-tuberculosis in general. Rest must be secured by thorough immobilization—by plaster of Paris or by some form of splint securing fixation or both traction and fixation, as in Sayre's knee-splint. No physiological use of the joint should be permitted.

If the patient must walk, he should do so only with crutches, the sound foot having been sufficiently raised by a high shoe to prevent that of the diseased extremity from coming in contact with the ground. If abscesses form, they should be opened if the local and constitutional symptoms are decided. Iodoform and chloride-of-zinc injections are of great service, but are not required in the majority of cases coming under early observation.

If non-operative treatment fails, the tubercular tissue must be removed by erosion, excision, or amputation. No absolute rule can be established as to the time at which and the conditions for which operation should be done, but at the present day, as the mortality attending erosion or excision is but slight, operations are done earlier than before and in much less desperate conditions of the joint, and the results therefore are better. Though every case must be a law to itself, it may be said in a general way that operation is indicated, (1) when the disease has been of relatively rapid development; (2) when in spite of rest and the ordinary constitutional remedies, employed for a reasonable length of time, the tuberculization of tissue is extending and the tubercular masses are softening and breaking down, and the patient is steadily losing strength and weight; (3) when the disorganization of the joint is extensive, as indicated by grating on movement, by abnormal freedom of motion from destruction of the ligaments, by abscesses and sinuses, and by profuse suppuration. Whether erosion or excision is the better operation, especially when the patient is a child, has not as yet been determined. Theoretically erosion is preferable, since it takes away only diseased tissue, and by sparing the region of the epiphyseal line does not interfere with the after-growth of the femur in length. But it is by no means easy thus to get rid of all the infected tissue, and unless this is done recurrence will certainly take place. Even when the joint is excised tubercular foci (Pl. XI, Fig. 2) may not seldom be left in the bone outside the line of section.

Amputation is called for only in those cases of extensive disorganization in which there has long been marked enfeeblement of the general strength because of pain and suppuration, or when excision or erosion has failed to arrest the local extension of the tuberculosis. In the former, especially in adults, removal of the limb is more likely to save life and enable the patient afterward to earn a living, and the operation is really conservative. Not seldom it has happened that though by removal of the joint the limb has been saved, it has proved only an encumbrance.

ANKLE-JOINT DISEASE.—Disease of the ankle-joint, if primarily of the articulation, is more frequently of synovial than of bony origin; if bony, the starting-point is more frequently in the astragalus than in the bones of the leg. Not very seldom it is in a malleolus, the outer rather than the inner. In many cases it is secondary to tuberculosis of the tarsus, and at times to disease of the sheaths of the tendons crossing the joint.

If synovial, the **symptoms** observed early are, interference with the free movement of the articulation and more or less well-marked fulness on the anterior surface outside the flexor tendons and on the sides of the tendo Achillis. If osseous, besides the intermitting inability or at least unwillingness fully to flex and extend the foot, there will be present for a time only the pain, spontaneous or elicited by pressure, which belongs to osteitis, following which expansion of the bone and intra-articular effusion will cause noticeable swelling. When the disease is well established the region of the joint has the globular contour with associated atrophy of adjacent parts that is so characteristic of fungous arthritis, and the foot is held in decided extension. The skin is pale, or deeply colored from congestion. Sinuses are developed comparatively late.

That the disease is not in the os calcis or in and about the middle tarsal articulation will be indicated by the locality of the swelling, below or in front of the ankle region.

The **prognosis** is that of tubercular arthritis in general, grave or not according to the age and constitutional state of the patient, and especially to the period of its recognition and the thoroughness of treatment.

Treatment.—As soon as the diagnosis is made, walking upon the foot should be stopped and the joint immobilized, care being taken in the application of the plaster-of-Paris bandage to place the foot at a right angle with the leg. The bandage must be renewed as often as the swelling subsides. After a time, if the disease still progresses, iodoform or zinc injections may be used with advantage. When the joint structures become disorganized, erosion or excision, typical or atypical, is indicated, and should be done without delay. Even when the tarsus has become extensively diseased and the tibia and fibula are infected beyond the epiphyseal line, removal of the tubercular tissue, both in the bone and in the soft parts, may be followed by recovery with a firm and useful limb. But such removal must be thorough, all diseased tissue being removed from the medullary cavity of the leg-bones, the tendon-sheaths, the meshes of the connective tissue outside the joint,—wherever it may be. If this cannot be accomplished, amputation should be done or the osteoplastic resection of Wladimiroff-Mikulicz. If the medullary canal is opened by amputation, all of the infected marrow must be thoroughly scraped out and the canal disinfected and drained.

SHOULDER-JOINT DISEASE.—The shoulder is much less frequently the seat of tubercular disease than might be expected from its range of movement and its exposed position. Children are at times attacked, but disease of this articulation is rare in them as compared with disease of the hip, knee, or elbow. Young adults are the more common subjects, though it is at times met with, and as a rule in a very destructive form, in persons well advanced in life. Any of the varieties of the disease may be seen; and *caries sicca* more often attacks this joint than any other (Fig. 57, p. 267).

The **symptoms** vary according to the form, though impairment of function is common to all. In other than the dry variety the affected region is enlarged and of globular shape, firm to the touch when fungous masses are present, fluctuating if there is intra-articular fluid in excess or if a periarticular abscess has formed. Such an abscess may point in the axilla, or, following the course of the muscles, on the anterior surface of the arm, on the side of the chest, near the posterior axillary fold, or over the scapula. Pain to a considerable degree may be present, and is often very severe in the ordinary dry variety when suppuration occurs. In *caries sicca*, except in those rare cases in which abscess is developed at a late period, there is no abnormal fulness of the region; on the contrary, the parts are greatly atrophied. Because of the destruction of the head of the humerus, unattended by excessive new formation, a hollow is produced under the acromion process which may excite a suspicion of luxation, all the more because of the existing undue prominence of the coracoid process. Movement, especially in adduction, is resisted, and even under an anesthetic is found to be much limited.

The **diagnosis** in any of the varieties and at any stage is often difficult and uncertain, the affection being confounded with bursal disease, with chronic rheumatism, or with hysteria, especially the last two. The history of the case and examination of the aspirated fluid will probably indicate the non-existence of bursitis. Chronic mono-articular rheumatism is not likely to be present in a young adult, and it is at such period of life, as a rule, that *caries sicca*

is found. In an hysterical joint there is no restriction of motion when the patient is anesthetized.

The **prognosis** is favorable in the majority of cases, particularly of the dry variety, especially if the parts are early put at rest and kept so.

Immobilization is essentially the only **treatment** required so long as abscesses do not form. When they have formed and the suppuration is free the head of the humerus will usually have to be excised. The final result of excision is ordinarily excellent, the new joint being firm and quite movable; sometimes it is very loose (flail-joint, dangle-joint), but even then it may prove serviceable.

ELBOW-JOINT DISEASE.—The elbow is tubercular much more often than either of the other large joints of the upper extremity. The disease shows itself usually in children, and is of synovial origin in the majority of cases. When osteal the primary focus is more likely to be in the epiphysis of the humerus than in that of the ulna or of the radius; in the latter it is rarely seen. Even when the joint disease is extensive the tubercular bone affection may be only on one side of the interarticular line, in which case the bone or bones on the other side will ordinarily be found decidedly rarefied.

FIG. 163.



Tubercular Disease of Elbow (original).

The **symptoms** here, as elsewhere, are not well marked in the beginning, especially in the osteal variety. Spontaneous pain may or may not be present, but pain can always be caused by pressure. There is some stiffness of the joint, and the forearm is somewhat flexed. As soon as effusion occurs into the joint or new formation to any decided degree takes place, fulness will be noticed on

the sides of the olecranon process and above it; not until much later on the anterior surface, because of the firm resistance of the overlying muscles and fasciæ. When the disease is well developed the region is markedly spindle-shaped, the arm and forearm much atrophied, the flexion permanent at an angle of about 140° , the hand pronated (Fig. 163). Increase of local heat may occasionally be recognized by touch. All movements are painful. If abscesses form they will probably open through the posterior surface of the joint.

Treatment.—As soon as the disease is detected the joint should be immobilized in flexion, the rectangular position being secured as soon as it can be tolerated—from the beginning, if it is not too painful. If abscesses form and open, the dressing must be so fenestrated as to permit of free discharge. Iodoform injections should be made through the sinuses into the abscess-sac or the opened joint-cavity; such injections or those of chloride-of-zinc solution may be made subcutaneously before sinuses have formed. After weeks or usually months of fixation of the joint, especially if it was commenced early, recovery may be expected; in the more fortunate cases it may be with quite complete preservation of the motions of the articulation, but much more often with ankylosis. It is because of the likelihood of the occurrence of a stiff joint that the parts should be fixed at a right angle, or even less—*i. e.* the angle at which the extremity will be most useful. When the joint has become extensively disorganized, erosion or excision should be done without delay. The result of such an operation at this joint is as a rule very satisfactory, excellent motion being often secured. Very rarely amputation of the arm will be required.

WRIST-JOINT DISEASE.—Except in connection with the same disease of adjacent parts, especially of the carpus, tuberculosis of the wrist-joint is rarely seen. Though it may be primary and synovial, it is commonly secondary to caries of the bones of the wrist, or, much less often, to fungous teno-synovitis. It attacks both children and adults, even persons beyond middle age. If primary, ordinarily it soon extends to the bones beyond the wrist, and even when first seen the case presents the symptoms of carpal disease. The joint motions are restricted and painful. The affected region is enlarged, especially on the dorsum, the forearm and hand being decidedly, often greatly, atrophied. The fingers are extended, seemingly lengthened. Disorganization takes place at a comparatively early period.

The **treatment**, as in like disease of other joints, is by immobilization and injection, by preference of the iodoform emulsion. Ignipuncture has been successfully employed by a few surgeons. If commenced early and steadily followed up, in a large proportion of cases treatment will effect a cure, though the wrist will almost certainly be a stiff one; but the time required is often very great, measured, it may be, by years. Because of this length of time and of the much-crippled or entirely useless hand that so often remains, it is as a rule wise to operate by erosion or excision if after several months of conservative treatment marked improvement in the local condition has not been secured.

SACRO-ILIAC JOINT DISEASE.—Disease of the sacro-iliac articulation (sacro-coxalgia) is of infrequent occurrence. It is very much more common in young adults than in children, and seldom appears in individuals over thirty-five years of age. It is likely to be mistaken for hip-joint disease. As a rule it pursues an unfavorable course. Its pathological changes are essentially the same as those of tubercular disease of other joints. There are the usual effusions (which if intra-articular are necessarily limited) and exudations, abundant new formation of infected granulation-tissue, destruction of cartilage and bone, and the development of cold abscesses, internal or external. The fluid of such abscess, if internal, may pass down behind the rectum into the ischio-rectal

fossa or by perforation into the bowels, or, following the muscular planes, may reach the neighborhood of the sciatic notch, of Poupart's ligament, or the upper part of the thigh, or may pass along the sciatic nerve to the region behind the greater trochanter; if external, the abscess will probably be found over the joint near the edge of the ilium. If an abscess does not form, recovery may be expected, with an ankylosed joint; if an abscess does form, especially an internal one, the probabilities are very strong that the patient will die, though he may even yet recover after extensive bone destruction and later fusion of the sacrum and ilium. When the affection has occurred in early childhood it may be the cause of pelvic distortion, of much importance in the female.

The **symptoms** are ill or well defined according to the stage of the disease. At an early period there will be discovered scarcely more than a little stiffness, discomfort in standing or walking for any length of time, and pain, which is neither constant nor severe, in the region of the joint or sometimes in the thigh. Later, at a time when the case is most likely to come under observation, pain is decided when any motion is made, and may be present when the patient is lying down. This will certainly be the case sooner or later when an attempt is made to rest upon the affected side. Crowding of the ilia together will always cause suffering. The pain is not simply in the region of the joint, but as a rule radiates in various directions, according to the course of the nerves that pass in close proximity to the articulation, especially the sciatic, the anterior crural, the obturator, and the genito-crural. The thigh is more or less flexed upon the pelvis, with tension of the psoas, and the patient throws his weight upon the sound side. The affected limb seems elongated, or there may be quickly alternating apparent lengthening and shortening. The patient walks with a decided limp. The soft parts over the joint posteriorly may be swollen or flattened. Usually after a considerable time the pus will show itself beside the anus, in the outer part of the groin, behind the trochanter, or near the iliac crest posteriorly; and before very long, if not opened by the knife, it will be spontaneously evacuated. True suppuration is very apt now to occur because of an added infection by the pyogenic cocci, with corresponding increase in the gravity of the previously existing constitutional symptoms due to the tuberculosis.

The disease is likely to be mistaken for neuralgia of the joint, for lumbago, for vertebral or sacral caries, for sciatica, and especially for hip-joint disease. The location, limitation, duration, and character of the pain will serve to distinguish it from the various neuralgic and myalgic affections. There will be an absence of the ordinary local signs of spinal caries. If there is caries or necrosis of the sacrum or ilium away from the articulation, there will probably be a history of severe injury, with the after-symptoms of bone contusion or wound. From hip-joint disease the differential diagnosis may not be readily made. The attitude of the patient, the flexion and apparent elongation of the limb, the pain, which, if present, will be located in front of or behind the hip, or even at the knee,—are all much like what is observed in morbus coxarius. But careful examination will show that the motions of the hip are unrestricted; pressure over the joint and crowding the head of the femur against the acetabulum will cause no pain if the ilium alone is steadily fixed; there is no adductor rigidity; if the expanded wings of the ilia are pressed together severe pain is produced, as it is by any motion of the limb the action of which is continued upward through the pelvis; there is steady pain in the region of the sacro-iliac junction; the anterior superior iliac spine on the affected side is more prominent and upon a lower level than that of the sound side.

The **treatment** will vary according as there is or is not an abscess. In the latter case rest and counter-irritation are of extreme value. The first is secured by fixation of the whole pelvis and the limb of the affected side by apparatus or plaster of Paris; the last by the application of the actual cautery. If this treatment fails and abscesses have formed, they should be evacuated and injected with the iodoform-glycerin emulsion, or freely opened if possible, curetted, and kept thoroughly drained. When the pain in the joint is very severe and the formation of an abscess is strongly threatened, free opening of the joint should be made, if necessary with the trephine. Of course all these operations must be done aseptically and the wound and cavities protected from septic infection; and rest, as absolute as possible, should be maintained until healing is complete.

Besides the tubercular affection, this joint is the seat also of rheumatic, gonorrheal, and septic inflammations. The first two are comparatively mild, and are usually recovered from, occasionally without ankylosis. The septic arthritis, very generally of puerperal origin, is almost certain to destroy life in a short time, in spite of any treatment, local or constitutional, that can be adopted.

(B) SEPTIC ARTHRITIS.

Infection by the bacteria of suppuration, chiefly the staphylococcus aureus and the streptococcus pyogenes, produces an acute arthritis which, if not promptly and actively treated, and sometimes in spite of treatment, results in destruction of the part and not seldom in loss of life. The infection may be produced in one of several ways: (1) directly through an open wound made by a dirty instrument, or one in which there is lodgment of a foreign body carrying the pyogenic cocci, or through a later infection of an originally aseptic track; (2) by an opening of a joint-cavity in the progress of an osteo-myelitis or by the extension of suppurative disease of the articular or periarticular structures; (3) through the transmission to and deposition in the synovial membrane of the micro-organisms present in the blood of a pyemic patient. However produced, if the infecting organisms are many and the case is left to itself, a high grade of inflammation of the joint structures is rapidly developed, with an abundant formation of pus. Exudation occurs into the synovial membrane, the subsynovial connective tissue, and the capsule, all of which soon become disorganized. The articular cartilages break down, either quickly in masses of considerable size, or more slowly at many points, through erosion by granulations. The ligaments soften to such an extent, it may be, as to permit of undue motion of the bones upon each other or of their complete luxation. The periarticular structures are filled with newly-formed infected granulation-tissue, in the breaking down of which abscesses form extending in various directions above and below the joint, and soon an opening through the skin takes place.

The **symptoms** are such as might be expected from the intensity of the joint inflammation. The pain is very severe, generally worse at night; the swelling is great; the skin is red and hot; fluctuation is distinct; the parts above and below are oedematous. The joint is flexed to the angle at which intra-articular tension is least. Any attempt at motion much increases the suffering. The constitutional symptoms are always grave, and are proportionate to the extent and rapidity of development of the local disease. There is generally an initial chill, or at least well-marked chilliness. The temperature quickly runs up several degrees, remaining high, with no very great fluctuations, or showing a well-defined septic curve. The pulse, strong and full it may be at first, soon becomes rapid and weak. The "typhoid" state, more or less complete, quickly sets in. In the very acute cases death from septicemia may occur

within a few days. Ordinarily with the opening of the abscesses and the resulting relief of tension decided improvement, at least for a time, takes place in the symptoms, both local and general. In those cases in which the joint affection shows itself in the course of a pyemia the chief local symptom is swelling; the joint, or not infrequently several joints simultaneously affected, becoming greatly distended with pus in the course of a few hours, the synovial membrane and the articular structures in general showing upon examination little or no evidence of being inflamed.

In the **treatment**, as in that of similar disease of bone, safety lies only in prompt opening up of the suppurating area, followed by thorough disinfection and subsequent free drainage. In some of the milder cases aspiration of the joint with antiseptic irrigation will arrest the progress of the disease; but, as a rule, it is much better to incise the capsule and thus secure the complete evacuation of the pus. Most rigid antiseptic treatment should be pursued until the parts are entirely healed, and the joint must be thoroughly immobilized, care being taken to correct as far as possible any existing displacement. Recovery is generally by ankylosis, often bony and complete; but occasionally, because of early and thorough treatment, the articular motions are preserved.

The constitutional treatment is that of suppurative disease in general—careful feeding and stimulation, quinine, and, later, such tonics as may be required. If the suppuration continues in an exhausting degree despite the local treatment adopted, and the joint is extensively disorganized, operative interference is demanded. Erasion may be done, or, better, atypical resection. Often the joint and the neighboring structures are so widely destroyed and the general condition of the patient is so bad that only by amputation can it be hoped to save life. The pyemic joint is commonly but a symptom of a constitutional state that will cause death in a few hours, or at most in a few days, and the arthritis demands no treatment. When the affection is of but moderate intensity, the articular complication should be treated in the ordinary way.

(C) INFECTIVE ARTHRITIS.

Very similar to the suppurative arthritis just described is that met with in connection with an acute infectious disease, such as small-pox, measles, scarlet fever, typhoid fever, or erysipelas. It is due to one or, in many cases, to both of two causes—viz. the presence in the joint of the ordinary septic bacteria, or the pyogenic action of the specific micro-organism of the existing disease, that of erysipelas being very closely akin to, if not identical with, the streptococcus pyogenes. The symptoms, prognosis, and treatment are the same as those of the ordinary septic joint inflammation. In the typhoid arthritis of the hip, which joint is especially likely to be attacked, spontaneous dislocation occurs in a number of cases. It is often produced spontaneously, sometimes by movements of the patient or by careless handling of the limb at a time when the capsule is largely distended with fluid and the femoral head consequently is to some extent lifted out of the acetabulum, and when the ligaments and muscles are greatly weakened.

But the suppurative is not the only form of arthritis found associated with the diseases mentioned, nor even the most common. Not very rarely during the height of the affection, more often in the period of subsidence and convalescence, a joint or joints (polyarticular involvement being usually a result of scarlatina or small-pox) will be found swollen, hot, and painful, as if affected with rheumatism. Such inflammation may be attributed in part to the affection

of the nervous system belonging to the disease, and in part to the irritative action upon the synovial membrane of blood containing the specific organisms, but still more to their chemical products. Resolution ordinarily takes place in the course of a few days, and no treatment is required other than keeping the parts quiet, enveloping them in cotton secured with a bandage, or making hot applications, simple or medicated.

(D) GONORRHEAL ARTHRITIS (GONORRHEAL RHEUMATISM, POST-GONORRHEAL ARTHRITIS).

Joint affections of several kinds are frequently found associated with gonorrhea. There may be often only a more or less severe intermittent arthralgia, which soon passes away; or there may be a chronic inflammation with abundant effusion into the joint-cavity (hydrarthrosis), chiefly that of the knee; or an acute sero-plastic arthritis; or a suppurative inflammation, which is comparatively rare.

For a long time the disease was called gonorrheal rheumatism, and even now it is generally so named. The joint affection, whether characterized by intra-articular effusion, by articular and periarticular exudations, or by the presence of pus, is not rheumatic, though a patient with gonorrhea may have rheumatism, and a rheumatic joint because of such antecedent disease may be more susceptible to the toxic action of the gonococcus or of the mixed gonorrheal and pyogenic infection. The more carefully the gonococcus of Neisser has been sought in the fluids and tissues of the affected joints, the more frequently it has been found, and in cases in which it cannot be detected there is good reason for believing that its ptomaines are the exciting cause of the metastatic arthritis. When joint disease of somewhat similar character is developed in non-gonorrheal urethral fever, as, *e. g.*, after the passage of a catheter or sound, it is possibly due to the taking up from the injured mucous membrane of the urethra of the common pyogenic cocci, or it may be due indirectly to their chemical products. The affection very rarely attacks women. It may appear at any period in the course of the urethritis, but occurs much more often in the third and fourth week than later, especially in its acute form. Any articulation may be its seat, though in nearly one-half of the cases it is the knee, and in about two-thirds the knee, the ankle, or the joints of the fingers or toes. Generally it is mono-articular; rarely more than two or three joints being attacked either at the same time or in succession.

The **symptoms** vary according to the form of the arthritis. In the chronic variety attended with abundant intra-articular effusion there is impairment of function, and, of course, marked swelling, but the joint is not painful or is but slightly so, except during the time of an acute exacerbation, which is occasionally observed. In the acute form the suffering is intense, persistent, worse at night, and much aggravated by movements, even slight ones. The parts are swollen and hot, the skin is red, and the joint is held in the position of greatest ease. Atrophy of the structures above and below is quickly produced. There are decided elevation of temperature and acceleration of pulse, and, because of the fever and suffering, rapid loss of strength and weight. When suppuration occurs, which is seldom, the local and general symptoms are intensified. The disease terminates in resolution, in ankylosis, or in destruction of the joint; most frequently by far in ankylosis (fibrous) either partial or complete, due to organization of the plastic exudations both articular and periarticular. The serous accumulation in the joint, in spite of any treatment, will often remain unchanged for many weeks, or it may be months.

In the **treatment** of gonorrheal as in that of other forms of arthritis rest is of prime importance. As long as there is any inflammation present the joint should be kept immobilized. Blisters, mercurial applications, fomentations, cauterizations, all of which have been employed again and again, can accomplish but a fraction of the good that results from the quietude and equable compression secured by the plaster-of-Paris bandage. But immobility of the joint must not be maintained for too long a time, lest ankylosis, to which, as has been stated, there is a strong natural tendency, be established; if on the other hand passive motion is too early resorted to, the inflammation will be lighted up again. The only safe rule to adopt is to keep the parts quiet until all inflammatory symptoms seem to have subsided, and then gently to move the joint. If the pain which follows disappears spontaneously within a few hours, twenty-four at the outside, no harm has been done, and the motions may be continued and increased. If the pain continues, the parts should be again immobilized for a time. An existing hydrarthrosis may be aspirated and carbolic-acid injections used. If suppuration occurs, aspiration and thorough antiseptic irrigation may be employed, and the joint then immobilized with a fair prospect of success. If such treatment is not quickly followed by marked amelioration of the symptoms, the cavity must be opened and drained as in suppurative arthritis due to other causes. Absorption of exudations and disappearance of adhesions, when not very close or strong, will be much favored by the employment of massage, baths, and douches continued for as long a time as may be necessary after the removal of the immobilizing dressings. If ankylosis has taken place, it must be broken up or the joint excised; such operation, however, will seldom be found necessary.

(E) RHEUMATIC ARTHRITIS.

Rheumatic articular affections are common, and are both acute and chronic. In the *acute* variety the joint inflammation is very rarely mono-articular, One or several joints may be attacked at first, and other joints are apt to be quickly affected, with at times rapid and complete subsidence of the inflammation in the articulations in which it was primarily located.

The **symptoms** are those of acute synovitis, pain, extreme sensitiveness to pressure, and heat and swelling due in part to effusion into the periarticular structures, but chiefly into the cavity. Suppuration never occurs unless there has been a mixed infection. As the arthritis is but a part of a general disease which is medical and not surgical, and ends with very few exceptions in resolution, leaving, at least after a single attack, no changes in the structures or the functional value of the articulation, it need not be here considered.

The *chronic* variety may be such from the start or may be the result of repeated acute attacks, each of moderate severity. The inflammation often causes no material alterations in the joint structures, the synovial membrane being only a little thickened and its vascularity diminished, with a diminution in the amount of synovial secretion and the production of a grating or creaking on motion as a consequence. On the other hand, there is occasionally an excess of fluid in the joint. At times the arthritis is decidedly plastic, the membrane, the capsule, and the periarticular structures being much thickened, with the formation of bands and adhesions restricting motion even to a considerable degree. The cartilages are usually unaffected, but may be irregularly thickened and thinned.

Treatment consists in the prevention of acute or more often subacute exacerbations which serve to increase the weakness and stiffness of the affected joint, and in the securing of absorption of the exudations and resulting adhe-

sions to such an extent as may be possible. The first is to be accomplished by avoidance of the exciting causes, cold and dampness, and by the proper protection of the joint by warm woollen clothing; the second by the employment of hot baths, frictions, and massage and due use of the joint, together with the internal administration of the ordinary anti-rheumatic remedies—the salicylates, the iodide of potassium, the salts of lithium, etc. Partial ankylosis should be broken up under ether, and followed by massage, the douche, and active and passive motion.

(F) GOUTY ARTHRITIS.

Whatever may be the essential nature of gout, its most constant manifestation is in the joints, in the smaller much more often than in the larger—*e. g.* those of the fingers, and especially the metatarso-phalangeal articulation of the great toe. Deposits of the urates, chiefly sodium urate, occur in the connective tissue of the joint; they produce destruction of the cartilages, unless it be true, as has been maintained by some, that the deposit can take place only in cartilage that is in a state of necrosis. As a result of the irritation consequent upon the presence of the abnormal salts, there is overgrowth of the connective tissue, with later contraction of the new-formed fibrous tissue, followed by alterations in the shape of the joint and impairment of its motions. Repeated attacks of acute inflammation occur, of greater or lesser intensity according to circumstances. Frequently the urates form masses of considerable size in the affected joint (*chalk-stones, tophi*), which may long remain without exciting any particular disturbance, may give rise to the formation of an abscess, or may often cause ulceration of the skin and exposure of the chalk-stone. As is the case in rheumatism, the joint affections of gout are but symptoms of a diathetic state, the consideration of which belongs to the physician rather than to the surgeon, except so far as they may produce disabling contractions and deformities.

(G) OSTEO-ARTHRITIS (CHRONIC RHEUMATOID ARTHRITIS, RHEUMATIC GOUT, ARTHRITIS DEFORMANS).

For many years a disease in certain respects much resembling rheumatism, in others resembling gout, has been recognized. As a rule having few exceptions, it is very chronic; goes steadily on from bad to worse; often produces extreme deformities; and disables its subjects, even to the extent of altogether preventing motion in the affected joints. Of the many names that have been given to it, that of osteo-arthritis is to be preferred. It is occasionally acute, when the patient is generally a young woman, though this form of the affection may be met with in children. The disease is ordinarily seen in middle or advanced life, even up to extreme old age. Women are more often attacked than men. Of the smaller joints those of the hands and feet, of the larger the hip and knee, are the ones usually diseased; as a rule, two or three of the larger joints are affected at a time; when mono-articular it is most frequently located in the hip or knee.

Its assumed causes are many. As predisposants there are heredity, a rheumatic or gouty family or personal history, long-continued hard work, mental worry, an occupation or residence favoring exposure. The exciting cause has been found in cold, in dampness, in injury, in the wretchedness of poverty, and in a trophic neurosis of undetermined origin, at times doubtless septic. It is one of the earlier degenerative affections, and anything that will impair the general strength may be a cause, especially anything weakening the nervous system. The poor are very subject to it, but perhaps no more so proportionately than the well-to-do, the privations of the one class being offset by the

nervous strains of the other. A curious illustration of the possible causative effect of dampness and want of sunlight may be afforded by the fact that the disease has been found in five out of sixteen skeletons of gorillas examined in various European museums, the native home of the gorilla being in the depths of the African forests; although more probably in this case the true cause is to be found in the abnormal and depressing effects of captivity.

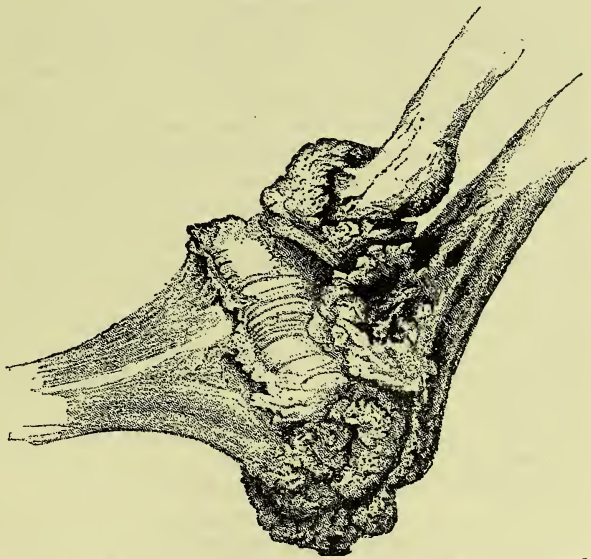
The advocates of the neural theory of causation believe that "the articular lesions are peripheral manifestations of a degenerative change in the center for joints situated in the medulla oblongata."

The articular cartilages are first affected. There occurs a fibrillary degeneration of the intercellular substance, with abundant new growth of the cartilage-cells, and soon a breaking down and disappearance of both, leaving the surface eroded and velvety, or, less often, smooth and thinned. By pressure of the adjoining bone marked central thinning is produced, the extent and precise location of which are determined by the pressure. Later there is complete disappearance of the cartilage and exposure of the underlying bone. This in its turn wastes away, with resulting changes in its shape. Not seldom the external layer becomes sclerosed, even of ivory-like hardness, and by pressure

is worn down uniformly or in grooves. While the central part of the articulating surface is wearing away, the peripheral is increasing in thickness, and grows out into lips hanging over the edge, which later partly or wholly ossify (Fig. 164). The synovial fringes enlarge, new ones form, and outgrowths are developed. The original cartilage-cells of the membrane proliferate greatly. Adhesions of adjacent sides of the fringes take place. Many of the outgrowths become pedunculated, and some of them may be detached, constituting one variety of "floating cartilage."

The capsule and ligaments, at first only congested and oedematous, after a time as a rule undergo fibrous degeneration, with later the formation of adhesions and contractions. They seldom ossify. Occasionally, instead of becoming harder and firmer, they soften and permit undue movement of the joint surfaces, even to the extent of the production of luxation. The irritated periosteum over the end of the affected bone throws out new bone, the osteophytes at times being numerous and of considerable length. The interior of the joint is generally dry, but occasionally contains fluid in large quantity (hydrarthrosis). Hernia of the synovial membrane may be produced, or a communication established with a neighboring bursa. Muscular atrophy occurs early. The tendons passing over the joint may harden and contract, may ossify,

FIG. 164.



Advanced Osteo-arthritis of the Elbow, with eburnated and grooved articular surfaces and enormous lips of bone (Moullin).

may become detached from the bone, or may soften and disappear. At the shoulder the long head of the biceps is commonly destroyed.

As the result of changes in the shape of the articulating surfaces, of new growths upon their edges, and of degeneration of the synovial membrane, the ligaments, the muscles, and the tendons, deformity and restriction of movement soon follow and become greater and greater. In the hand, where the disease so commonly manifests itself, pronation occurs, with the fingers strongly inclined to the ulnar side and held in flexion or extension. On the sides of the finger-joints, especially the distal ones, there may generally be found small, hard, pea-like nodules (the nodosities of Heberden). In certain very mild cases the knobbed condition of the fingers may be almost the only observed indication of the existence of the disease. Several of the vertebræ or all of them may be tied together by a bridge of bone, often said to be produced by an ossification of the anterior common ligament, but really by a new formation in place of the ligament, which has undergone absorption. In a few cases almost every joint in the body has been found firmly fixed, the patient being incapable of movement. While all these changes are going on in the joint there are very slight or even no constitutional disturbances present. Suppuration does not take place either in or about the joint, except in rare cases.

The **symptoms** of the chronic variety, when the disease is well developed, are unmistakable, the only other affections likely to be thought of being chronic rheumatism and gout. The coexisting enlargement and distortion of several joints; the grating and creaking on movement; the slow progress of the malady; the long continuance of the ability to go about and attend to business; the absence of severe pain; the normal temperature and pulse; the want of the proper symptoms of rheumatism and gout,—all these taken together render the diagnosis easy and certain. In the acute variety, occurring generally in children and young adults, the intensity and rapid development of the disease, the symmetrical joint involvements, the articular enlargements, and the early manifestation of muscular atrophy indicate the nature of the affection. When only a single joint is affected—and this is, as has been stated, far more often the hip—the diagnosis for a time may be uncertain. Like the other varieties, it is generally seen in old persons (*malum coxæ senile*), but is occasionally met with in young subjects. It frequently follows contusion, as from a fall on the trochanter. Nothing specially abnormal may be noticed for a time, but after a number of weeks or even months the limb will be shortened and the joint motions much restricted. Such a case has often been mistaken for an old unrecognized fracture of the neck of the femur. Long ago it was described by Bell as an “interstitial absorption” of the neck, but in such cases not simply an interstitial but a general and extensive absorption of both head and neck has taken place, with the formation of new bone along the neck in substitution of that taken away. The destructive and formative changes about the joint are in no material respect different from those observed in the ordinary polyarticular variety.

Of late Spender has called attention to certain symptoms that are developed early, before any distinct evidence is afforded of articular changes. These are (1) rapidity of the heart's action and increased arterial tension, due to disturbance of the inhibitory action of the pneumogastric; (2) the appearance of bronzed and discolored patches upon the skin; (3) clamminess of and atrophic changes in the skin because of vaso-motor disturbances; (4) pain in the muscles of the ball of the thumb or along the inner side of the wrist. The importance of these symptoms, if they prove to be constant ones, is very great, as only at an early stage is the disease curable. When joint changes to any considerable

extent have taken place, the damage is irreparable, and, probably, further progress of the malady cannot be arrested.

The treatment must be by the removal as far as possible of all depressing causes, the improvement of the general nutrition, and the administration of drugs and the employment of measures that will promote absorption. Cod-liver oil is of much value, as is arsenic in the early stages; later on arsenic has proved to be decidedly injurious. The iodides, especially that of iron, are beneficial, as are electricity, baths, douches, and massage. Various thermal and sulphur springs have enjoyed considerable reputation as affording relief. Blisters and other strong counter-irritants, especially the actual cautery, have been employed, but it is very doubtful if they ever do much good. If hydrarthrosis is present, compression or better aspiration and carbolic injections should be employed. Here is the one great exception to the rule of securing rest to a diseased joint. Immobilization is *not* indicated, but active and passive movements should be employed as long and as freely as possible.

(H) NEUROPATHIC ARTHRITIS, OR TABETIC ARTHROPATHY (CHARCOT'S DISEASE).

Since it was first described by Charcot in 1868 a peculiar osteo-arthritis in patients affected with locomotor ataxia has been frequently observed. The joint changes are in the main those of osteo-arthritis in general, but there are certain differences of importance. The disease is much more acute, and affects chiefly the large joints, particularly the knee. There is little or no pain, and constitutional disturbances are absent. Without any injury having been received, the joint suddenly swells, and soon a large intra-articular effusion occurs, which after a time disappears through absorption or organization. Extensive and at times very rapid ulceration and wearing down of cartilage and bone take place. New formations are as a rule very limited, though an hypertrophying variety is sometimes met with. The lesion often extends some distance up the shaft, and pieces of bone are separated as though there had been a comminuted fracture. Marked grating and crackling even on slight movement are perceived early. The ligaments quickly break down, with resulting great mobility, it may be in every direction. Dislocation, or characteristic deformity without complete luxation, occurs. Great atrophy of the affected limb is soon observed. All these changes may take place while the patient is confined to bed, proving conclusively that the rapidity and extent of the lesions are not due to over-use of an osteo-arthritic joint the sensibility of which has been greatly diminished or practically altogether lost because of the existing tabes. Ordinary osteo-arthritis may occur in a tabetic patient, but it does not run the acute course that is so characteristic of tabetic arthropathy proper. That the disease does not depend upon degeneration of the peripheral nerves is shown by the absence in a considerable proportion of cases of any marked changes in such nerves. Everything seems to indicate that the disease is a peculiar one, depending upon changes that have taken place in the spinal cord, perhaps in the anterior horns.

The treatment is practically confined to protection of the affected joints from injury, and to limitation of the abnormal movement by position or by apparatus. If dislocation of a joint in the lower extremity has occurred, it will probably be necessary for the patient to keep his bed. In a few cases excision has been done, but the results have not been satisfactory.

(I) HYSTERICAL JOINTS.

More than half a century ago Brodie directed attention to cases of seeming

articular disease in which no joint lesion was present, and which were only manifestations of hysteria. Since then such cases have been found to be of frequent occurrence. In the great majority of instances the patients are women, especially young women. Generally they are well educated, in easy circumstances, and highly impressionable, often the subjects of some ovarian or uterine disturbance. The knee and hip are the joints commonly affected; the trouble may come on suddenly and without known cause or after a slight injury, or follow a mild arthritis which has quickly disappeared. The patient imagines that she has serious disease which causes great local distress and decidedly or entirely prevents passive motion except at the cost of much suffering. Active motion may seem as impossible as though the muscles were paralyzed, or, as is usually the case, may be executed without special difficulty, but in a rather feeble way. The parts are generally normal in size and appearance except as affected by a slight amount of atrophy from disuse, or are at times somewhat swollen and a little reddened, commonly because of the applications that have been made. There is great hyperesthesia of the skin, the least touch causing pain, much more than that produced by firm pressure. There may be an apparent rigidity of the muscles about the articulation, but this at once and completely disappears when the patient is anesthetized. The joint may from the first be held fixed in extension or flexion, but will rarely be found at that angle of flexion which secures the greatest ease and which is characteristic of a true arthritis. Very often the position of the limb varies from time to time, the change, it may be, occurring suddenly.

The local temperature is normal, or even subnormal, because of the sluggish circulation, though transient and variable increase of heat may be noticed that may even appear quite regularly at certain hours of the day. It is of the highest importance that the true nature of the affection should be determined at an early period. These cases are often misunderstood, and the patient is treated for actual articular disease, traumatic, rheumatic, or even tubercular, and in consequence becomes a permanent cripple.

The **diagnosis** is to be established by observing, first, the marked disproportion existing between the subjective and the objective symptoms, a disproportion so characteristic of all manifestations of hysteria; second, the intense hyperesthesia; third, the absence of any evidence of degeneration of the tissues; fourth, the complete relief of symptoms when the attention of the patient is directed from herself and her malady; and fifth, the entirely normal outline of the joint and complete freedom of its motions during the anesthetic sleep. It should not be forgotten that in any case of suddenly appearing disease of the knee or hip in a young woman, especially if she is of a neurotic temperament, the antecedent probabilities are all in favor of the hysterical nature of the affection. But before concluding that it is of such nature care must be taken to make sure that there are not in and about the joint evidences of an organic lesion. The extreme difficulty at times of learning the real character of the disease and the deceptive character of this neuro-mimesis or nerve-mimicry are shown by the fact that in some cases surgeons have commenced an excision or amputation only to find upon exposure of the joint structures that there was nothing the matter with them.

The **treatment** is constitutional, supporting, and tonic, and directed to any existing visceral disease. Moral treatment is especially needed. Unless the confidence of the patient is gained and she realizes the truth of the statement made to her that she has no joint disease, she will not get well. Of local treatment the less the better. Electricity, frictions, baths, massage, all are very apt to keep the attention of the patient fixed upon her affection. The

joint should never be immobilized, and no brace of any kind should be applied, as fixation of the articulation will almost certainly cause the formation of disabling adhesions. Hypnotic suggestion has been found curative in certain cases.

SECTION IV.—NEURALGIA OF JOINTS.

Neuralgic pain in a joint may be due to constitutional or to local causes—*i. e.* to disease of the brain or spinal cord; to neurasthenia; to malaria; to syphilis; to nerve injury; to pressure upon the main trunk high up or upon branches near the articulation by a tumor or an inflammatory new growth; to affection of organs more or less remote, as in the hip in cases of uterine or ovarian disease. Like similar pain elsewhere, it is intermittent and variable in intensity, and is unassociated with any apparent permanent change in the articular or periarticular structures. It is to be treated in the ordinary way, by improvement of the hygienic surroundings, by regulated exercise, and by the therapeutic or operative removal of the existing cause. In a few cases it has been asserted that there has been a neuralgia, generally located in the knee, so intense and so persistent that it could be relieved by nothing short of nerve-stretching, neurectomy, or amputation. It may well be questioned if some or even all of these cases were not really hysterical affections instead of arthralgias. Occasionally peripheral neuritis consequent upon traumatism, the pressure of a tumor, or disease of bone has given rise to arthritis that has ended in ankylosis and deformity.

SECTION V.—WOUNDS AND INJURIES OF JOINTS.

Wounds of joints are of two classes, *non-penetrating* and *penetrating*. The former are of little importance as long as they do not suppurate, but when they suppurate there is danger of extension of the inflammation to the joint. If attended with loss of substance, the resulting cicatricial contractions may more or less interfere with articular movements. However slight such a wound may be, it is wise to stop all motion of the joint, to clean and close the opening, and to apply an antiseptic compress. In a few days complete repair may be expected.

Penetrating wounds, on the other hand, are always serious accidents. If they are properly treated recovery follows in a large proportion of cases; if improperly treated or neglected they are almost certain to result in local destruction, not seldom in loss of life. Aside from compound dislocations and complicated fractures, which are considered elsewhere, they are generally produced by gunshot, by stabs, or accidentally by tools of trade. In a few cases in originally non-penetrating injuries communication with the joint is established later, often through a bursa.

The **symptoms** vary according to the nature of the vulnerating body, the joint opened, and the extent of the injury, though there will be always observed a discharge of synovia more or less mixed with blood, and in a short time swelling of the parts from hemorrhage and intra-articular effusion. The discharge of synovia in small quantity, however, is not pathognomonic, since it may come from an unconnected bursa; but if synovial fluid to any considerable amount is poured out, penetration of the joint should be accepted as a fact. In large wounds the articulating surfaces can be seen or felt. Pain and bleeding are always present in greater or less degree, but are not indications of penetration, as they are equally associated with wounds that do not open the cavity. If protected from septic infection, the opening in the capsule readily closes, the effused serum and extravasated blood are absorbed, the synovitis quickly subsides, and recovery takes place with little or no impairment of the functional value of the part, though some weakness and a slight

restriction of motion are apt to continue for a time. When such a wound is made by an unclean instrument, or if at any time before healing it becomes septic, the symptoms are very different and the prognosis is grave. By the end of about the third or fourth day after the receipt of the injury, or at such period as infection of a primarily aseptic wound may occur, the symptoms of suppurative synovitis, already described, become manifest. If promptly and vigorously treated, the joint may and generally will be saved, though probably in a decidedly damaged condition. It is not in the fact that the wound involves an articulation, but in the risk of its becoming septic, that the great danger lies. Here, as elsewhere, every effort must be directed toward preventing this occurrence.

By far the most dangerous of the joint wounds are those produced by **gunshot**. In military surgery until recently, whether the articulation was extensively crushed by the passage into or through it of a large ball or piece of shell or opened by fissuring of the extremity of the wounded bone, unless amputation or excision was primarily performed a suppurative arthritis was developed within forty-eight or seventy-two hours, and quickly proved fatal, or was recovered from only after weeks or months, and that with a greatly damaged limb. When only the joint was injured there might be produced an articular empyema, or the pus, travelling along the connective-tissue planes or the tendon-sheaths, widely infected the soft parts. How far under the peculiar circumstances attending the receipt and early treatment of joint wounds in war it may be possible by "first aid" and after antiseptic treatment to prevent such wounds from becoming septic is a question as yet unsettled, though the limited experience of a few surgeons in late wars renders it highly probable that very much may be accomplished.

But in civil life, in which the wounds are commonly produced by pistol-balls, it has been clearly shown that under proper treatment the joint injury in the great proportion of cases may be conducted to a safe termination, even to the extent of preservation in large measure of the articular movements.

Treatment.—Such a wound should never be examined with dirty fingers or a dirty probe. The track of the ball and the probable extent of the damage done should be determined only with an aseptic instrument or a thoroughly cleaned finger. As a rule having very few exceptions, a piece of cloth carried in with the ball can be detected only by the finger, and the presence of such a foreign body is almost absolutely certain to infect the wound. The opening and the track being enlarged if necessary, all foreign bodies and all completely detached pieces of bone should be removed and the wound carefully disinfected as after compound fractures. A drainage-tube should then be introduced, through and through drainage being secured if required. Antiseptic dressings should then be applied and the joint immobilized. When the bone injury has been so extensive as to necessitate operation, atypical rather than typical resection should be done.

As in the larger wounds in war, so in the smaller ones in civil life, the fate of the part if not of the wounded man himself is in the hands of him who first sees him; in other words, if septic infection is prevented a good recovery may be expected. If the wound becomes septic the cavity and the suppurating tracks about must be opened up and thoroughly cleaned, sequestra removed as they become separated, and proper general treatment pursued. Ankylosis of the joint, frequently complete, is the ordinary termination if part and life are saved.

Sprains.—By far the most common joint injury is sprain. This is produced by a sudden wrench or twist of the articulation, and is experienced most frequently in the ankle and wrist, in the former because of a misstep or a fall

upon the foot, in the latter because of a fall upon the hand. Its degree may vary from that which is so slight that its effects quickly subside to that which is associated with luxation or fracture or both. The line of displacement may pass through any section of the investing capsule, according to the mode of production of the injury, but it most often is through that part in which motion is physiologically least; hence in the hinge-joints it is lateral. By the abnormal movement the synovial membrane is unfolded on one side and compressed on the other, and when the normal limit of such change is reached the membrane is torn and crushed. The ligaments, though their fibers cannot stretch, do elongate somewhat as a change is produced in their structural reticulations (as illustrated in the Indian puzzle), but the limit is quickly reached, and further extension produces laceration. The degree of tearing varies according to the severity of the wrench, from that of only a few fibers to that of the entire ligament, to its detachment from the bone, to the production of fracture or dislocation, and to rupture of distant muscles. Laceration of the vessels and slight or extensive hemorrhage into the joint-cavity, the meshes of the articular structures, and the connective tissue outside necessarily occur. Intra-articular extravasation to any considerable amount is indicative of severe injury and adds greatly to the gravity of the case. The accident is most common in young and middle-aged adults, is most likely to affect a joint that has previously been sprained, and is much more easily produced in a deformed limb or one in which the muscles are feebly developed and the ligaments relaxed; hence its frequency in the weak-ankled.

The **symptoms** are well marked, the only question, as a rule, being whether or not the case is a simple sprain or whether there is an existing luxation or, more often, fracture. Pain is instantly produced, and is always severe. Not very rarely the patient faints. After the first sharp attack there occurs a period of comparative ease, followed, either quickly or more commonly after the lapse of some hours, by a return of suffering, due to tension and inflammation. Before long the parts become swollen. If there is much hemorrhage into the joint-cavity, the fulness may be observed within a very short time, but ordinarily only after a few hours; it is then due in part to extravasation, but chiefly to effusion into the cavity of the joint and the periarticular structures. The swelling is especially noticeable in those parts of the articulation in which there is least pressure exerted by tendons and ligaments. Movement of the joint is arrested either wholly or in large measure. If the ankle or the knee is affected the patient cannot walk at all, or can walk only with a limp. After a time, usually several days, subcutaneous extravasations are seen, with resulting color-changes in the skin. If in a hinge-joint a lateral ligament has been completely torn across, the gap may commonly be felt, and an abnormal movement of the joint can always be effected. Laceration of a muscle can be detected by touch, as also can a fracture with or without separation of the fragments, as in the lower end of the radius or through a malleolus. In the ankle, as pointed out by Callender, "sprain fracture" may occur. This is a fracture of a part of the articular surface. Its existence cannot be discovered by touch. This accident explains many of the cases of ankylosis of the ankle following what is apparently a mere sprain.

The **prognosis** varies with the joint affected, the extent of damage done, and especially the promptness and efficiency of treatment. When there has been a large hemorrhage into the cavity, blood-clots often remain for a considerable time; occasionally their organization and fusion with the adjacent synovial membrane result in adhesions which decidedly restrict the after movements of the joint.

The **treatment** has for its object, as far as possible, the prevention or the limitation of the inflammation in and about the joint. In the milder cases rest, with cold or, much better, hot applications, may be all that will be required. Compression is of decided service, a layer of cotton or wool being wrapped around the joint and held in place by a moderately tight bandage of flannel or rubber. After the active inflammation has subsided, massage is of great value, and its early employment is advised by many surgeons. Free active and passive motion of the joint from the first, as has been strongly advised by some, is painful, and cannot be otherwise than injurious when the sprain is a severe one. By far the best treatment, as a rule, is immobilization of the joint by the application of a plaster-of-Paris bandage. If applied soon after the accident has occurred, it will very much lessen congestion, hemorrhage, and effusion, and diminish the time of confinement. If there has been a large amount of blood poured out into the joint, it should be withdrawn through an aseptic aspirator needle before the dressing is applied. One great advantage of this method of treatment is that it will permit of the patient's going about and attending to business if necessary—on crutches if the sprain is of the knee or the ankle, with the arm in a sling if the affected joint is of the upper extremity. Immobilization applied at once and maintained for a number of weeks, especially if the patient is kept quiet and the limb elevated, will in great measure prevent the occurrence of the weak, swollen, painful, and crippled condition of the joint that so often follows a severe sprain treated in other ways. Even if there has been a fracture or a dislocation, this method of treatment is the best that can be employed.

Ankylosis.—As the result of cicatricial contractions of new-formed granulation-tissue in and about a joint, its motions are restricted, and the articulation is said to be ankylosed. Limitations of movement due to loss of substance in the skin and underlying soft parts consequent upon severe injuries, or due to contractions of muscles and tendons, are not, properly speaking, cases of ankylosis, though they are at times associated with the ankylosing effects of articular and periarticular inflammation, and, it may be in marked degree, increase the disability due to such inflammation.

That ankylosis may be produced, there must have been (1) a blood-clot adherent to the folds of the synovial membrane which later has become fused with them; or (2) the organization of an exudate within the joint commonly attached to eroded parts of the articular cartilage, though at times deposited only in an interosseous ligament; or (3) similar change in an exudate in the subsynovial and interligamentous connective tissue; or (4) degeneration of ligaments, with after-contraction of the substitution granulation-tissue and the formation of adhesions to the adjacent parts; or (5), what most often occurs, a combination more or less extensive of two or more of these conditions. Until a few years ago it was believed that simple disuse of a joint would be followed by ankylosis, but this is now known to be an error, at least as to the larger joints. Without inflammation of some form or other, ankylosis cannot take place. The restricting band or bands may be of limited extent outside the cavity and of considerable length within, or they may be very extensive in and about the capsule and very short between the ends of the bones. The inflammation may terminate, as it commonly does, in the formation of fibrous tissue, or may go on to ossification, partial or complete. When the latter change has taken place within the joint-cavity, where osseous union is generally found, there must have been a prior opening up of the cancellous tissue of both the articulating bones. If the bone deposit is external, it may occupy the place of a degenerated ligament and adjacent connective tissue, having started from the periosteum and passed over the

joint as a natural splint altogether preventing any movement; or it may be in patches, larger or smaller, in the parts outside the synovial membrane.

According to the degree of organization of the new-formed tissue, ankylosis is *fibrous* or *bony*; as respects the extent of restriction of movement, it is *partial* or *complete*.

Except when, as after certain fractures and in cases of osteo-arthritis, the ankylosis is due to displaced fragments and stalactitic outgrowths, or when there has been but a limited bone deposit in the periarticular structures, bony ankylosis is a complete one. It is not, however, by any means always associated with entire obliteration of the joint-cavity, for, as has already been stated, there may be only an outside bridge; and when the union is an internal one very often there will remain for years or through a long life a small synovial cavity. The fusion of the articulating bones is seldom so complete that the line of junction is not recognizable on section, but occasionally it is impossible to find where one bone ends and the other begins, even the medullary cavities being so directly continuous as to constitute but a single one.

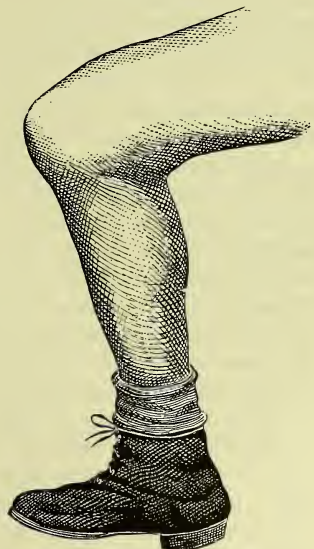
Bony ankylosis is commonly a termination of septic (often an osteo-myelitic) or tubercular inflammation, while fibrous ankylosis, which may be met with after any form of joint inflammation, is very generally due to a traumatic, a gonorrheal, or a rheumatic arthritis.

In the fibrous variety the adhesions may be so extensive and short as practically to prevent all motion at the joint, or so lax as to interfere but little with the ordinary movements; or, as is more commonly the case, they may be sufficient decidedly to limit the use of the limb. In the cases in which this variety most strongly resembles the bony, even when motion at the articulation cannot be recognized, its fibrous nature is proved by the pain attending manipulations and the manifestation within a few hours of the symptoms of irritation or inflammation, especially a local rise of temperature.

The *ill effects* of an ankylosis are proportionate to the resulting interference with the physiological use of the joint; they depend, therefore, not only on restriction of motion, but also, and to a greater extent, on the angle of fixation. A knee completely ankylosed in the straight position is much better than one held in permanent flexion or one which is movable and yet cannot be fully extended (Fig. 165). An ankylosis of the elbow that prevents the forearm from being flexed at a right angle with the arm is much more crippling than one in which extension cannot be carried beyond a right angle. At the shoulder, ankle, and hip loss of motion is often compensated in a great measure by the free movement of the scapula, at the knee, and at the sacro-iliac junction respectively. When ankylosis occurs in a young child more or less interference with the after-growth of the bone may be expected.

The *treatment* will depend upon the variety, the angle, and the joint affected. When the nature and extent of an articular inflammation make it probable that ankylosis will occur, such inflammation should be limited as

FIG. 165.



Angular Ankylosis of the Knee
(Bradford and Lovett).

much as possible, especially by rest: care, however, must be taken not unduly to prolong immobilization, particularly in cases of rheumatic origin, in which after a time regular passive motion should be made. In certain fractures, notably those about the elbow, it has been advised by many practically to disregard the fracture after a few days, and by passive motion prevent the joint from becoming stiff; but it is better to treat the fracture in the ordinary way, remembering that immobilization most thoroughly limits inflammation, and that the adhesions are due to inflammation. Both at the elbow and at the knee (after fracture of the patella) a resulting fibrous ankylosis, if forcibly broken up, will commonly be quickly reproduced, but with active use of the joint will generally spontaneously disappear in the course of a few months or at most in a year or two. When the ankylosis is bony and the position a good one, no treatment should be pursued, unless it be at the elbow, where by excision, partial or complete, a serviceable movable joint may often be secured. When the angle is a vicious one, excision should be done or the malposition corrected by osteotomy; at the hip the latter is much the preferable operation. Forcible breaking down of bony adhesions should never be done; destructive inflammation of the part is very likely to follow, the original disease having been almost certainly septic or tubercular; and if it does not, the surfaces will unite again by bone.

By massage, by frictions, by baths, by regulated movements, by the use of electricity, especially by massage and movements, much may be accomplished in the removal of periarticular exudations and adhesions.

But in the majority of cases a fibrous ankylosis will require for its removal either a forcible rapid breaking up of the adhesions and straightening of the limb or a slowly-effected correction of the deformity by continuous or intermittent traction, by weight-extension, or by apparatus. As a rule, the former method is to be preferred. If the tendons about the joint are contracted, they should be divided a few days before the straightening is to be done, so that the little wound of the skin may be entirely healed, as otherwise it may be a starting-point for an extensive laceration. Very generally the tendons are only contracted, and that more apparently than really, and will yield readily enough when the limb is extended. When it is the knee that is the seat of the difficulty, as is so often the case, the patient may be upon his back or prone; in the latter position leverage can more readily be exerted. The limb being grasped above the ankle and above the knee, firm, steady movements in flexion and extension are to be made until the leg can be fully and easily extended upon the thigh, when the whole limb is to be enveloped in cotton and immobilized by plaster of Paris, the dressing being kept on for two or better for three weeks. During the straightening the rupture of the adhesions can be both felt and heard. The operation is usually free from danger and followed by little or no local or constitutional disturbance.

But accidents, and serious ones, may occur. The main vessels may have become shortened and adherent, and may be ruptured when the limb is straightened; or there may be laceration of one of the popliteal nerves, with resulting paralysis; or the skin and adherent fascia may be extensively torn; or long-encapsulated pyogenic cocci may be set free and develop extensive suppuration in the leg or thigh. No one of these accidents is to be expected; any one of them may happen. Because of the danger of setting free the infecting organisms and producing destructive inflammation of the joint and structures outside, forcible breaking up of ankylosis following either septic or tubercular disease should not be done. By the employment of weight-extension or by an apparatus permitting of a gradual widening of the abnormal angle the deformity can usually be corrected after a time.

SECTION VI.—LOOSE BODIES IN JOINTS.

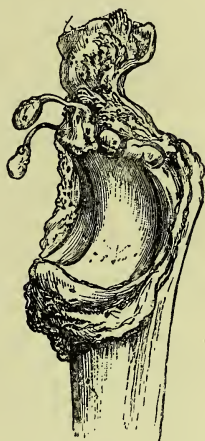
Loose bodies sometimes occur in the larger joints, in nine cases out of ten in the knee. They consist of fibrous, bony, or cartilaginous tissue or a mixture of them. So commonly are they cartilaginous that they are often called by the general name of "floating cartilages." They are sometimes free in the cavity of the joint, or less frequently attached by a long or a short pedicle (Fig. 166). Occasionally they are multiple, but more commonly there are only one, two, or three. In size they vary from that of a pea or bean up to that of the last joint of the thumb. When multiple they are usually very small. They are developed in several ways, originating (1) from villous outgrowths from the synovial membrane, which are more and more crowded off from the surface, the contained cartilage-cells growing, and after a time often ossifying in the center; (2) from detached osteophytes of osteo-arthritis; (3) from outgrowths from the articular cartilage; (4) from detached pieces of cartilage, with or without a bony substratum, which have been separated either by sudden violence or slowly by "quiet necrosis;" (5) from blood-clots, either in the cavity itself or much more probably in the synovial villi; (6) from fibrin poured out in an acute inflammation, or, much more often, in a rheumatic subject, over a limited space under the synovial membrane, which it pushes inward until pedunculation and later separation of the nodule take place; (7) from overgrowth of the cartilage-cells normally contained in the synovial membrane; (8) from detached tuberculized fringes or small parts of the infected membrane. The first is by far the most common origin, the others being rare, most of them (3, 5, 6, 7) very rare. By many it has been denied that the floating cartilage ever is a piece chipped off the articulating end of the bone, but sufficiently numerous specimens prove that this accident occasionally occurs.

However produced, they usually undoubtedly follow traumatism, which is often slight, or else are associated with a rheumatic or osteo-arthritic diathesis. They are found in adults under middle age as a rule, and in men far oftener than in women. When very small and numerous they are not usually attended by other symptoms than those of chronic arthritis. When there are but one or two, and these of considerable size, they demand treatment because of the pain and disability produced by them. Occasionally by pressure they produce absorption and erosion of the bony surface with which they are in contact.

Symptoms.—Sooner or later the presence of such a body is followed by a slight weakness and fulness of the joint, the patient at times feeling the nodule at various parts of the joint, oftenest in the neighborhood of the patella. Occasionally the cartilage will be caught somewhere between the femur and the tibia. Instantly pain is experienced, so intense, it may be, as to cause nausea and fainting. Motion of the joint is arrested, and the patient perhaps falls. The inability to flex or extend the joint continues until the loose body is dislodged by various movements. Moderate or often considerable effusion into the joint-cavity soon occurs, but is quickly absorbed, the joint then resuming its previous condition. Similar attacks follow one another with increasing frequency, and after each the recovery is progressively less complete, until finally the effusion becomes permanent, and the joint is markedly weakened.

The **diagnosis** is, as a rule, easy. A small body which slips away from under the finger can be detected first in one and then in another part of the joint.

FIG. 166.



Nodules of Fibro-cartilage attached by Elongated Pedicle (Marsh).

When it cannot be felt its presence can only be inferred from the sudden attacks of disability. The only affection with which it can be confounded is the so-called "internal derangement of the knee-joint," which is caused by the slipping or dislocation of one of the semilunar cartilages. This also causes a sudden, intensely painful arrest of motion at the knee, followed by acute synovitis; but the joint is more likely to be held in the locked condition, and after the effusion has subsided an irregularity can usually be detected just above the border of one of the tuberosities of the tibia. This is the edge of the semilunar cartilage, dislocated forward or backward.

Treatment.—When such a sudden attack of pain and disability occurs, the loose cartilage must be displaced by forced flexion and extension at the knee, under an anesthetic if necessary, after which the joint should be immobilized for a number of days. The only radical treatment is removal of the loose body by opening the joint. Modern antiseptic methods have made the operation a perfectly safe one, in marked contrast to the very serious results which formerly followed the opening of this joint. The loose body is first to be fixed, if possible, either by the fingers or by a steel pin thrust into it, often a procedure of great difficulty owing to its density. An incision is then made directly into the joint, as near the cartilage as possible. This is pressed out, or if any difficulty is experienced the finger or a blunt hook or forceps is passed into the joint and the cartilage seized. The edges of the wound in the synovial membrane are to be united by buried catgut sutures, and the cutaneous wound is closed and dressed as usual. The leg should be immobilized either by a plaster-of-Paris dressing or a splint.

SECTION VII.—DISPLACED SEMILUNAR CARTILAGE.

This has long been termed "internal derangement of the knee-joint," but is now known to be due to the slipping or displacement of one of the semilunar cartilages, most frequently the internal. It may occur in health, the coronary ligament being torn away; but it is commonly associated with chronic synovitis or osteo-arthritis, in which diseases the attachments of the cartilages are relaxed and more easily torn. The cartilage may be merely slipped between the ends of the bones, or it may be rolled upon itself and entirely detached from the tibia. Having once occurred, the accident is liable to be frequently repeated.

The **symptoms** are sudden and severe pain, with inability to stand or walk, the leg being partially flexed and the joint locked. Swelling follows quickly, but subsides after displacement of the cartilage. When the luxation has occurred frequently, however, the effusion is more permanent and the limb weak.

Treatment.—At the time of the accident replacement of the cartilage is effected by flexion and extension with rotation of the knee, if necessary under an anesthetic. Sometimes the patient will execute this maneuver himself better than the surgeon. Occasionally replacement is impossible. When the cartilage has been replaced the joint quickly resumes its normal condition, an elastic knee-cap being often employed to steady and assist it. If the disability is very great or reduction impossible, the joint should be opened and the cartilage seized and brought back to its normal position, where it should be fixed by sutures carried through the periosteum of the tuberosity. It has been removed with excellent functional results. Absolute asepsis is required.

CHAPTER VIII.

DISLOCATIONS.

DEFINITIONS.—A dislocation is a permanent, abnormal, total, or partial displacement from each other of the articular portions of the bones entering into the formation of a joint.

A *temporary* displacement, followed immediately by a return to place, constitutes a **sprain**.

When the opposing articular surfaces are completely separated or touch each other only by their edges, the dislocation is complete; lesser forms of displacement are termed *partial* or *incomplete*, or **subluxations**. In the ball-and-socket joints the dislocation is said to be complete when the center of the globular head rests outside the rim of the concave socket.

A coexisting wound of the soft parts that establishes communication between the outside air and the cavity of the joint makes the dislocation **compound**; and the coexistence of other important lesions that seriously affect the treatment and prognosis makes it *complicated*.

When the corresponding joints of a bone symmetrically placed on both sides of the median line of the body, as the lower jaw or a vertebra, are dislocated, the dislocation is said to be *bilateral*. It is total when both ends of a bone, as the clavicle, are dislocated, or when a small bone having several joints, as a carpal or a tarsal bone, is widely displaced. Dislocations are *double* when symmetrical on both sides of the body, as of both shoulders. Dislocations are said to be *multiple* when two or more bones are simultaneously dislocated, as two or more fingers, a shoulder, and a hip. Both these last two terms are sometimes used in the sense of total.

Ordinarily a dislocation is *traumatic*, and occurs abruptly in a normal joint as the result of external violence or of the sudden contraction of the patient's muscles upon the bones forming the joint, but occasionally it takes place gradually (or suddenly) without recognizable violence in joints that have been so altered by disease as to facilitate the displacement; such dislocations are commonly known as *spontaneous* or *pathological*. *Congenital* dislocations are those that occur during intra-uterine life, and are usually the result of defective development.

NOMENCLATURE.—As a general rule, the *distal* member of the joint is the one said to be dislocated; thus we speak of a dislocation of the humerus, and not of the scapula, when the scapulo-humeral joint is dislocated; an almost universal exception to this rule is the term dislocation of the outer end of the clavicle, used instead of dislocation of the acromion or of the scapula. Sometimes the name of the joint or of the region is used, as dislocation of the shoulder, hip, elbow. Terms indicating direction correspond to the change in the position of the distal segment of the joint, as backward dislocation of the elbow, meaning that the upper ends of the radius and ulna are displaced backward. Special names indicative of the new relations of the displaced bones are applied to some of the commoner varieties, as subcoracoid dislocation of the shoulder, iliac or dorsal dislocation of the hip.

STATISTICS.—Dislocations are less frequent than fractures in the proportion of 1 to 10; those of the shoulder are the most frequent, those of the elbow

next. The proportions vary in different statistics, but in general terms it may be said that *dislocations of the shoulder constitute from one-half to two-thirds of all dislocations.*

AGE.—Dislocations may occur at any age from the very moment of birth; the absolute frequency is greater between the ages of twenty and thirty; the relative frequency, computed according to the number of people living at the different ages, is greatest in the three decades between forty and seventy. Below the age of twenty years dislocations of the shoulder are rare, those of the elbow frequent; above that age those of the elbow are rare, those of the shoulder frequent. It has been pointed out that dislocations of the elbow are produced in childhood by the same violence—*i. e.* falls upon the outstretched hand—that produces fracture of the humerus in adults, and dislocations of the shoulder in adults by that which produces fractures of the clavicle in children—*i. e.* falls upon the shoulder.

ETIOLOGY AND MECHANISM.

The causes are (*a*) *predisposing*, and (*b*) *immediate* or *determining*.

(*a*) **Predisposing Causes.**—*Normal* predisposing causes are found in the conformation of certain joints which diminishes the area of contact of the opposing articular surfaces in certain positions or establishes conditions of leverage favorable for the rupture of opposing ligaments, as in hyper-extension of the elbow; or which avoids the opposition of ligaments, as in the movement forward of the condyles of the lower jaw; and also in the greater exposure of certain joints to external violence. Normal freedom of motion is more of a protection against dislocation than a predisposing cause thereto, because the necessary rupturing strain is not ordinarily put upon the opposing ligaments before the limit of motion has been reached. A predisposing cause at the elbow is found in the outward deviation of the forearm from the long axis of the arm. *Pathological* predisposing causes are distention of the joint by an effusion, destruction or softening of the ligaments by violence or disease, and the fracture of bony processes or of one of a pair of parallel bones.

(*b*) **Immediate or Determining Causes.**—These are external violence and muscular action. *External violence* may be exerted directly upon the end of the bone that is displaced, as in a dislocation of the head of the humerus by a fall or a blow upon the prominent part of the shoulder; or indirectly through and parallel to the shaft of the bone; or in a more complex manner by moving the limb beyond the normal limit of the range of motion, so as to rupture the ligaments, and then forcing the liberated bone out of its place.

Muscular action dislocates by communicating a momentum to the limb which acts in the same manner as external violence when the limit of the range of motion is reached, or by acting directly upon the end of the bone to draw it out of its socket. Thus a woman dislocated her shoulder by raising her arm quickly to strike a blow, a man dislocated both shoulders by drawing himself upward by his hands, another by raising his arm to paint a ceiling, others during epileptic convulsions; dislocation of the lower jaw may be produced by yawning. Some individuals can voluntarily dislocate certain joints by the contraction of certain muscles or groups of muscles; in others a liability to dislocation of some one joint by slight causes exists (recurrent or habitual dislocation) as the result of a primary traumatic dislocation, or of the paralysis of certain muscles, or of other pathological conditions.

PATHOLOGY OF RECENT DISLOCATIONS.

Except in very rare instances, one or more of the ligaments of a joint and its capsule are torn during a dislocation; in the ball-and-socket joints the rent in the capsule is on the side toward which the round head of the distal bone is displaced; in other joints the ligaments on either side or on both sides may be torn, the position and extent of the injury varying with the mode of production and the range of displacement. There is reason to think that both the capsule and the ligaments escape rupture in the simpler dislocations of the lower jaw, and a few cases have been reported in which those of the shoulder have similarly escaped. In joints relaxed by paralysis of the corresponding muscles or by an effusion within the capsule, dislocation habitually occurs without laceration.

Attached muscles that are put upon the stretch may be ruptured or torn from their attachments, perhaps bringing with them in the latter case the scale or apophysis of bone to which they are attached. Opposing prominences of bone or portions of a prominent articular edge or rim may be broken off, as the coronoid process of the ulna or the edge of the head of the radius in a backward dislocation of the elbow, or the rim of the glenoid or cotyloid cavity. One articular surface may be deeply indented by impact against the edge of the other surface.

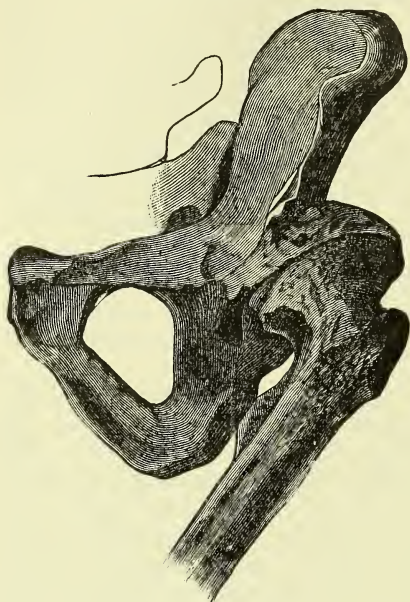
Associated injuries of adjoining parts may exist as **complications**. The shaft of the dislocated bone or of a parallel bone may be broken; the dislocated end may be split; the neighboring blood-vessels or nerves may be ruptured or bruised; adjoining organs may be lacerated or compressed; the soft parts and the integument may be torn. Fracture of the shaft or of the neck of the dislocated bone may constitute a serious, perhaps an insurmountable, obstacle to reduction, because of the difficulty of communicating the necessary movements to the dislocated end; the commonest example is fracture of the surgical neck of the humerus in combination with dislocation of the shoulder. Fracture of the articular end of the dislocated bone is rare, although there is reason to think that limited bruising of the head of the humerus by impact against the edge of the glenoid fossa is not very uncommon. Partial fracture of the rim of the socket of an enarthrodial joint or avulsion of an apophysis is common, and does not ordinarily constitute an important complication. Rupture of neighboring blood-vessels is most frequent at the shoulder, where it usually consists in rupture or avulsion of the subscapular or circumflex artery. Of injuries of nerves the most common is that of the posterior circumflex at the shoulder. At the knee and the elbow the main arterial, venous, and nerve trunks are occasionally torn. Injuries of adjoining viscera are rare. In backward dislocation of the sternal end of the clavicle the trachea or œsophagus is sometimes pressed upon; and in one reported case the dislocated humerus was forced through the wall of the chest, the bone retaining its new position and the patient surviving many years.

In uncomplicated cases **reduction** is habitually followed by repair of the torn capsule and ligaments, but complete restitution to the normal condition may be prevented by faulty repair of some of the lesions, by periarticular thickening, by subperiosteal formation of bone in the young, or by more or less persistent sensitiveness of the joint. Thus at the shoulder the ruptured tendon of the supraspinatus and the upper part of the capsule may fail to reunite, and the patient be thereby exposed to frequent recurrence of the dislocation, or the fracture and retraction of the greater tuberosity may annul or weaken the power of active external rotation, or injury to the circumflex nerve may result in more or less prolonged paralysis and wasting of the deltoid. At the

elbow the stripping up of the periosteum from the posterior aspect of the external condyle may lead to such thickening of the bone as will limit extension.

In dislocations that remain unreduced the displaced and lacerated connective tissue becomes thickened and condensed about the head of the bone,

FIG. 167.



Old Supracotyloid Dislocation of the Femur, with very complete new acetabulum (Kronlein).

sometimes uniting directly with it, sometimes forming a new capsule about it which is more or less broadly continuous with the old one; the torn ligaments and muscles contract new adhesions which serve to fix the bone in its new position and limit its motion. The untorn portion of the capsule is drawn across the other articular surface (*e. g.* the glenoid fossa), and, if the contact is close, unites permanently with it; if the contact is not close, the cavity of the socket fills up with fibrous tissue of new formation. The dislocated head comes to rest against an adjoining surface of bone, and under the influence of its pressure the bone and the periosteum are stimulated to the production of new bone about the point of contact, and thus is formed a bony rim, a veritable new socket, possibly covered with fibro-cartilage (Fig. 167). The ossifying process may extend to the adjoining soft parts and produce large and irregular masses of bone continuous with one and possibly with both of the members of the joint.

A very important feature is the occasional binding fast of neighboring large vessels or nerves to the dislocated bone. The result of all these changes is that the dislocated bone becomes permanently fixed in its new position, and its return to its former one can be effected only with lacerations similar to, and usually much more extensive and serious than, those which accompanied its first displacement; furthermore, the socket from which it was displaced has been shut off by the adherent capsule or filled up with new tissue.

SYMPTOMS.

Deformity, including in this term changes in contour and attitude, is always present, and is frequently so marked as to be almost diagnostic on inspection alone. The one demonstrative sign of dislocation is the recognized *presence of the head of the bone in an abnormal position*; and this sign should always be sought for in preference to others that are less demonstrative, but perhaps more easily recognized. It is obtained by palpation of the region, by systematic exploration of the bony prominences, and by the identification of abnormal prominences or of those abnormally situated, by means of gentle movements communicated to the limb. Thus in the common anterior dislocation of the shoulder the finger recognizes the absence of the normal bony resistance offered by the head of the humerus below the acromion in front, and finds a new one below or to the inner side of the coracoid process, which shares in rotatory

movements communicated to the arm; and the surgeon also notes that the axis of the limb if prolonged upward passes through this prominence.

Measurements.—Many confusing statements concerning shortening or elongation of the limb in different dislocations have been made. Error may arise through failure to place the compared limbs in symmetrical positions, contradiction through the choice of different lines of measurement. It may be positively stated that, with one or two extremely rare exceptions, such as dislocation forward of both bones of the forearm, *shortening* can always be found if the measurement is made on the proper side and with the limb in a suitable attitude. The proper side is the one away from which the head of the bone has been dislocated; the suitable attitude is the one in which the limb is inclined toward this side. Thus, at the shoulder the measurement should be made from the tip of the acromion to the external condyle of the humerus, and the arm should be in abduction. Fig. 168 illustrates the sources of error and contradiction. *A* represents an anterior dislocation of the right shoulder seen from in front; *A'*, the same shoulder with the bones in place. Measured in abduction, *B C* is shorter than *B' C'* or *B D* or *B' D'*; measured with the arm alongside the chest, *B D* is as long as, perhaps longer than, *B' D'*.

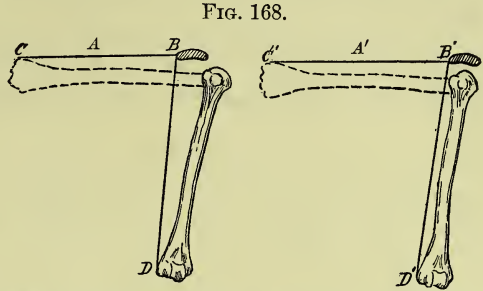


FIG. 168.
Diagrams to show the effect of attitude upon the measured length of the arm (*A*) in dislocation of the right shoulder, and (*A'*) when the bones are in normal position; *B*, *B'*, the acromion (original).

In typical dislocations, those in which certain ligaments and portions of the capsule remain untorn, the *attitude* of the limb is characteristic, because of the limitation of movement imposed by the untorn bands: thus in the common anterior dislocation of the shoulder the elbow is held away from the side; in the common dorsal dislocation of the hip the thigh is flexed and adducted.

As the consequence of this opposition of the untorn ligaments, the *normal range of motion* is restricted in certain directions while it is unaffected in others. In the hinge joints the normal range of motion is restricted and abnormal lateral mobility exists. The statement is frequently made that mobility is increased in fracture and diminished in dislocation. In that form the statement is entirely misleading: ordinarily the mobility that is found in fracture is wholly abnormal and exists between two parts of the same bone; the mobility whose absence or restriction is noted in dislocation is mobility between two separate bones. Normal mobility may be restricted, both in fractures and in dislocations, by the opposition of the muscles aroused by fear of pain. In dislocation of the elbow backward abnormal lateral mobility exists, just as it does in fracture of the lower end of the humerus.

The production of the dislocation is usually accompanied by severe *pain*, which may persist for some time or may promptly give place to a feeling of soreness, with pain when the member is moved or the region handled. Persistence of severe pain appears to indicate that some of the soft parts are not torn, but are kept forcibly stretched.

Treatment.—As a rule, a recent dislocation should be *reduced* at the earliest practicable moment. The conditions which may make delay advisable are great inflammatory reaction and swelling and great shock, due usually to

associated injuries, which may contraindicate the infliction of pain or the use of anesthetics.

The choice of a suitable **method of reduction** depends upon the recognition of the obstacles to reduction. In most cases these are of two kinds: the contraction of the muscles, excited by pain or the fear of pain, and the resistance offered by untorn ligaments or portions of the capsule to movements of the limb in certain directions. Other obstacles are the interposition of a portion of the capsule, common in certain dislocations (*e. g.* the metacarpo-phalangeal), but rare in others, and unusual relations to certain adjoining muscles created by a wide movement of the dislocated bone.

In "typical" dislocations, those in which the limb assumes and retains a characteristic attitude, which has been shown to be due to the action of untorn ligaments or portions of the capsule in resisting movement in certain directions,

FIG. 169.

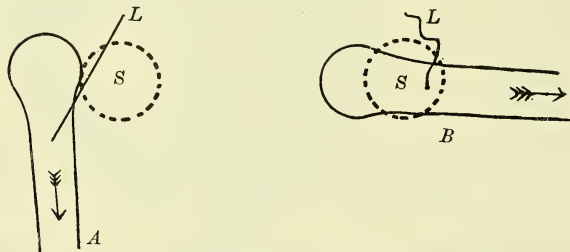


Diagram to show the effect of the position of a limb upon the tension of a ligament (original).

it is essential that the limb should be placed in a position and moved only in a direction in which the opposition of these untorn structures will not be encountered. Fig. 169 shows diagrammatically the position (A) in which the ligament (L) opposes and that (B) in which it permits the movement of

the limb in the direction indicated by the arrow, and by which the head would be restored to its socket (S). In "atypical" dislocations the laceration of the ligaments and capsule is so extensive that they offer little or no opposition to movement in any direction. In the typical forms, therefore, certain well-defined manipulations are needed whether anesthesia is or is not employed to remove the opposition of the muscles; in the atypical forms reduction is usually very easy by moderate traction and coaptation, without special attention to the attitude of the limb during the manipulation.

Reduction by manipulation is a term applied to a succession of gentle movements communicated to the dislocated limb by which the sides of the rent in the capsule are separated from each other and the head of the bone is rolled back into place by the aid of the untorn ligaments. The method is applicable only to typical dislocations, and the best-known examples are Kocher's method for the reduction of anterior dislocations of the shoulder, and Bigelow's for that of dorsal dislocations of the hip, the details and mechanism of which will be described in the appropriate places.

The opposition of the muscles, by which is meant a persistent contraction of those attached to the dislocated bone which prevents its movement toward its socket, may be annulled by **anesthesia**, or overcome by forcible or persistent traction, or avoided by momentarily distracting the patient's attention. The use of anesthetics has made the reduction of most dislocations very easy. It should be pushed to the point of complete muscular relaxation: this is sometimes obtained during the short period of primary anesthesia which usually precedes by some minutes the condition of complete anesthesia, and in the simpler cases reduction may be then obtained; but if the manipulations are likely to be at all prolonged, or if the patient is feeble or diseased or suffering

from shock, it is safer to wait for complete general anesthesia. The proportion of cases in which death has followed the use of an anesthetic in the reduction of dislocations is exceptionally large, and seems probably to be due to its timid and insufficient use; the anesthesia not being complete, the reduction causes dangerous shock by pain. Such, at least, appears to be the explanation of the disproportionate fatality of minor but painful operations under an anesthetic. Ether is safer than chloroform for the purpose.

The use of **pulleys**, which formerly was general, is now rare in the reduction of recent dislocations, having been replaced by anesthetics or by the prolonged application of moderate traction, the muscles yielding gradually to fatigue. This gradual traction can be made by a weight and pulley or by india-rubber, or, in some cases, by the weight of the dependent limb in a suitable position. Even without anesthesia, if the attention of the patient be diverted the muscles will sometimes be seen to relax, and then by a sudden sharp blow the bone may be replaced.

In cases in which reduction is prevented by the **interposition** of a portion of the capsule, as at the metacarpo-phalangeal joint, or of a muscle or tendon, as occasionally at other joints, an open arthrotomy may be necessary. Under the protection of antiseptics this operation is reasonably safe, but the risk appears to be least, in the case of the larger joints, if it is done while the injury is fresh, on the first or second day, or, failing this, if it is postponed to a much later period, after the reaction has subsided and the extravasated blood has been reabsorbed, about the third or fourth week.

In **old dislocations** the manipulations used in recent ones will sometimes succeed after the adhesions that bind the dislocated bone in its new position have been ruptured by forcible movements of the limb, but usually strong traction is also required to draw the bone to its place. Interference in such cases is unavoidably blind and uncertain; more extensive lacerations are necessary to free the bone than those occasioned by the original dislocation, and the changed relations of important vessels and nerves are such, and their fixation by cicatricial tissue is so firm, that serious injury may be done. It seems much safer, therefore, in many cases to resort to a cutting operation if the attempt is to be made to restore the bone to its place. Furthermore, the structural changes, are occasionally so great that even if the dislocation is reduced the condition of the joint will fall far short of the normal, and the limb, in such cases, will be no more useful than while the dislocation existed. Hence in some instances it is as well to let the dislocated bone remain unreduced.

The **accidents** that may follow attempts at reduction are numerous and varied. The skin may be torn by excessive and improperly applied traction, the bone may be broken, vessels and nerves may be ruptured, suppuration may be excited, and death may follow through the agency of the anesthetic or the shock of the manipulations.

Fracture of the bone may occur, and may involve the shaft, the neck, or the bony prominences, the fracture of the olecranon in old backward dislocations of the elbow being the commonest example of the latter. It has been noted that the bones of a dislocated limb sometimes show exceptional fragility, apparently the result of interstitial changes provoked by disuse or altered conditions of nutrition consequent upon the primary injury.

Injuries of vessels are most frequent and important in the common forms of anterior dislocation of the shoulder, and of these the commonest appears to be the rupture of the subscapular or circumflex artery or its avulsion from the axillary. The axillary artery itself has been torn completely across, or its inner and middle coats ruptured; the axillary vein has rarely been injured.

Rupture of an artery at the shoulder is followed by rapid extravasation of blood in the axilla; pulsation at the wrist may persist. The condition is a grave one: of 47 cases 31 ended fatally (Stimson). Methods of treatment that have proved successful are digital pressure, ligature of the subclavian, and disarticulation at the shoulder. Double ligature at the point of injury has been uniformly fatal.

Injuries to main nerves are more rare: the roots of the brachial plexus have been torn out in reducing a dislocation of the shoulder; in some cases paralysis of the limb has followed reduction.

Syncope and sudden death have also followed reduction in a very few cases: in some of them it was probably due to rupture of a vessel or of large nerves; in one case fat embolism of the lungs was found.

After-treatment.—After reduction of a dislocation no other treatment is usually required than immobilization of the limb for a few days in a suitable position, and the subsequent avoidance for a few weeks of attitudes which would favor recurrence. In dislocations of some joints (clavicle), and in certain forms of dislocations of others, the tendency to recurrence is so great that special measures are requisite to prevent it. Passive motion if made at all should be kept within a painless range.

The condition of **habitual dislocation** can hardly be relieved except by operation.

CONGENITAL DISLOCATIONS.

Under this term are included certain dislocations which do not appear or are not recognizable until after the lapse of some months or years, but the causes of which—faulty development of the joint, paralysis, etc.—are supposed to have existed at birth. From it are excluded those traumatic dislocations which are produced *in utero* or during delivery.

Congenital dislocations of the hip (Fig. 170) are by far the most frequent, about 90 per cent. of all; they are much more common in females than in males, the proportion, according to different statistics, varying from 60 to 90 per cent. One or both joints may be involved. The typical congenital dislocation of the hip is due to a defective development of the acetabulum as carried on by the Y cartilage, which permits the head of the femur to pass, under the influence of the weight of the body or of the contraction of the muscles, upon the dorsum of the ilium. Exceptional cases in which it passes upon the pubes or into the obturator foramen have occurred, but they are very rare. Usually the head of the femur is smaller than normal and the neck short. As the child begins to walk, the changes increase, the displacement is finally arrested, and compensatory changes in the attitude of the pelvis and spine appear, the upper part of the pelvis being tilted forward, and the lumbar spine showing a marked curvature forward. If only one hip is involved, the child limps in walking; if both are involved, there is no limp, but the attitude of the body and the gait are peculiar. The tilting of the pelvis disappears when the child is recumbent or when the thighs are flexed; the shortening of the thighs can sometimes be overcome by traction.

Of the reduction of such a dislocation, in the usual sense of the term, there can of course be no question, for the normal structure of the joint does not exist, and the most that can be attained is to diminish the deformity and functional disability. Much has been gained in some cases by traction continued for many months, by which the head of the femur has been drawn nearer the acetabulum and fixed there by condensation of the tissues about it, and perhaps by the growth of a new bony rim or socket on the ilium. Palliative

measures have also been usefully employed in the form of firm corsets of felt or leather which kept the pelvis from tilting. In some unilateral cases the affected limb has been kept fixed in abduction, so as to make it relatively longer in walking. Operative measures, usually the creation of a socket by chiseling, have of late been resorted to with a fair measure of success. For a description and discussion of the various methods and their results the reader is referred to papers by Bradford and Myers in the *Annals of Surgery*, August, 1894, and by Kirmisson in *Revue d'Orthopédie*, 1894, No. 3. The conclusions reached by Bradford are: (1) That the methods of treatment by traction or by mechanical means, with or without tenotomy, do not effect a cure; (2) that correction by forcible reduction without incision can be applicable in but few cases and is not reliable; (3) that operative reduction offers the best prospect of a cure. The method at present, however, involves risks and is not certain in its results, but it is to be expected that further experience will give greater precision and more certain results. The shortened condition of the Y-ligament forms an important obstacle to complete reduction, and these fibres should be thoroughly divided; this can be better done by incising them from in front than from behind.

Among the rarer forms of dislocation of the hip found at birth or appearing shortly thereafter are those due to dropsy of the joint *in utero*, and those succeeding paralysis of one of the groups of muscles. In such cases a reduction may perhaps be effected, and the surgeon's efforts must then be directed to preventing its recurrence. Congenital dislocations at the *shoulder* appear also to be due to defective development of the glenoid fossa.

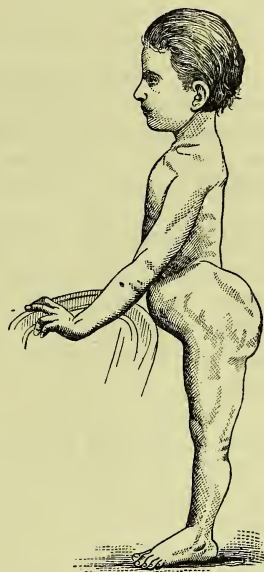
Among congenital dislocations of the *knee*, the most frequent is that in which the leg is in extreme hyperextension, the foot sometimes resting against the abdomen. They have usually been easily corrected.

SPONTANEOUS DISLOCATIONS.

Under this term are included those in which the dislocation occurs, usually without external violence, as the result of predisposing changes in the articular surfaces or in the ligaments or of the unopposed action of certain muscles, others being paralyzed. Those due to destruction of the bones are incidents of the diseases that produce the destruction, and will not be considered here. Those due to dropsical distention of the joint are of more importance, for they are capable of reduction and may easily escape notice at first. They occur in the course of the eruptive fevers, less frequently in that of the continued fevers (Keen) or of articular rheumatism, and are most common at the hip. The effusion in the joint makes the occurrence easy; the habitual attitude in bed, the patient's position, resting on his side with the thighs flexed and the upper one adducted, is also favorable, and the contraction of the muscles usually does the rest.

Paralytic or "*myopathic*" dislocations are most common at the shoulder.

FIG. 170.



Double Congenital Dislocation of the Hip (Stimson).

The weight of the limb being unopposed by the scapular muscles, the head of the humerus sinks and is easily displaced forward or backward.

SPECIAL DISLOCATIONS.

DISLOCATIONS OF THE LOWER JAW.

These constitute about 4 per cent. of all dislocations, are more frequent in women than in men, and may be unilateral or bilateral. The displacement is forward, the condyle resting in front of the eminentia articularis at the root of the zygoma. This forward displacement is an exaggeration of the normal forward movement of the condyle in opening the mouth. The interarticular fibro-cartilage may accompany the condyle or may remain behind, its anterior attachment to the condyle being torn.

Dislocations *backward* are very exceptional, a few cases having been reported in which, by a blow upon the chin, one or both condyles have been driven backward, breaking through the anterior wall of the external auditory meatus. By a similar blow very rarely the condyle has been driven into the cranial cavity. In what follows only the forward dislocations are considered.

The usual cause of *forward* dislocation is the wide opening of the mouth, either voluntarily in laughing, yawning, or introducing some large object, or in manipulations about the mouth, as by a dentist. Fixation is due to the passage of the condyle in front of the line of the lateral ligaments, the attachments of which to the jaw are exceptionally low. The internal pterygoid and masseter aid in the fixation, partly by maintaining the elevation of the angle of the jaw and partly by opposing the backward movement that would aid reduction. The engagement of the coronoid process of the inferior maxilla in front of the malar bone, which has been alleged to be a cause of the fixation, rarely occurs, if ever.

The **symptoms** are inability to close the mouth, some projection of the lower jaw, and the presence of the condyle in advance of its normal position. In unilateral dislocation the chin is deviated to the opposite side and the interference with function is less.

Theoretically, the dislocation should be most easily **reduced** by opening the mouth more widely to relax the lateral ligaments, and then pressing the jaw backward; but the involuntary contraction of the muscles, unless the patient is anesthetized, will be a serious obstacle. A fairly successful method is by forcible pressure with the thumbs downward and backward upon the lower molar teeth. In bilateral dislocation it is sometimes easier to make reduction on each side separately.

The liability to frequent recurrence which sometimes ensues has been combated by opening the joint and suturing the meniscus to the periosteum at the margin of the articulation. The injection of tincture of iodine into the joint has also been proposed.

DISLOCATIONS OF THE STERNUM.

Dislocation of one of the normal segments of the sternum from another is a rare injury, and one not always to be distinguished clinically from a fracture. We describe dislocation of the body from the manubrium, and of the ensiform process from the body.

DISLOCATION OF THE BODY FROM THE MANUBRIUM.—The lower border of the manubrium is on a line joining the sternal ends of the second costal cartilages, which articulate with both segments. Dislocations forward and

backward have been observed, the former being the more common. Forward dislocation has been caused by direct violence (a blow upon the sternum), by indirect violence (compression of the sides of the chest), by muscular action (the effort made in exercising on parallel bars), and possibly by forced dorsal flexion of the trunk. It may be complete or incomplete. In the complete form the lower fragment may override the upper one as much as an inch, the anterior fibro-periosteal envelope being torn and the posterior one being stripped from the second segment. The costal cartilages retain their attachments to the manubrium. Backward dislocations appear to have been caused only by direct violence received upon the second segment. Either form is frequently associated with dislocation or fracture of the ribs or of the costal cartilages.

The general **symptoms**, interference with respiration and circulation, may be very severe. The **diagnosis** is made by recognition of the change in the anterior aspect of the sternum and of the relations of the line of separation to the second costal cartilages. In forward dislocation the shallow depressions at the upper corners of the body for articulation with the second costal cartilages may be recognized. The well-known gravity of the injury appears to depend mainly on associated lesions.

Reduction is made by forcible dorsal flexion of the trunk and direct pressure on the projecting fragment. In one or two instances it has been aided by the coughing of the patient or by his making a deep inspiration. In some cases in which the dislocation has remained unreduced it has caused no disability.

DISLOCATIONS OF THE ENSIFORM PROCESS are very rare; the apex may be directed either forward or backward. The most prominent symptom in some cases has been persistent vomiting, relieved by drawing the apex of the process forward with the fingers or with a sharp hook introduced through the skin.

DISLOCATIONS OF THE RIBS AND COSTAL CARTILAGES.

DISLOCATION OF THE HEAD OF THE RIB.—Nine cases, several of them verified by autopsy, have been reported, the head of the rib having been thrown forward by a blow upon the rib from behind. In one the head had been forced through the pleura into the lung.

CHONDRO-COSTAL SEPARATION.—A half-dozen examples of this injury are on record; the causes have been external violence and prolonged or violent coughing. The **treatment** is the same as that of fracture of the rib or cartilage.

CHONDRO-STERNAL AND CHONDRO-CHONDRAL DISLOCATIONS.—A few cases of dislocation of the costal cartilages from the sternum or from each other have been reported, besides those associated with fracture or dislocation of the sternum. The causes have been external violence received upon the chest and muscular action exerted through the pectoralis major. Both forward and backward displacements have been observed; the former were easily reduced by pressure, but readily recurred.

DISLOCATIONS OF THE CLAVICLE.

The clavicle may be dislocated at either end or at both ends simultaneously.

STERNAL END.—The joint possesses an intra-articular fibro-cartilage which has its strongest attachment above to the upper edge of the end of the clavicle, and below to the cartilage of the first rib. The clavicle may be dislocated forward, backward, or upward, in this order of frequency.

DISLOCATION FORWARD appears to be most frequently caused by forcible movement of the shoulder downward and backward, in which the center of the clavicle comes to rest upon the first rib, and the inner end is thus thrown forward as the outer one is lowered and carried backward. In cases of habitual dislocation the bone slips out of place when the arm is raised beside the head or when the shoulder is thrown back as in putting on a coat. In a case reported by Stimson the liability to displacement was gradually developed in a youth of nineteen years, so that it occurred whenever the elbow was raised to the height of the shoulder, the bone returning to its place as the arm was lowered. The dislocation may be complete or incomplete: in the former the end of the bone rests upon the front of the sternum to the inner side of or below its normal position. Occasionally a piece is broken from the end of the clavicle or the edge of the articular surface of the sternum.

The **symptoms** consist in the marked projection and abnormal position of the end of the clavicle, with local pain, sinking of the shoulder downward and inward, and inability to use the arm.

Reduction is effected by drawing the shoulder backward and by suitable pressure on the end of the clavicle; and recurrence is prevented by immobilization of the shoulder. This is the difficult part of the treatment, and many plans have been tried, such as a figure-of-8 bandage about the two shoulders, the turns crossing on the back; prolonged rest in bed upon the back to avoid the influence of the weight of the arm in reproducing the displacement; moulded caps of leather or gutta-percha fitted to the end of the clavicle and held in place by straps about the chest; and direct pressure by a hernial truss the pad of which rests upon the end of the clavicle while the spring passes to the back under the axilla of the uninjured side.

The liability to recurrence may be extremely troublesome. In Stimson's case it was overcome by three injections of a dram of alcohol into the peri-articular tissues at intervals of a fortnight, the arm being meanwhile confined to the side of the body. The same condition subsequently developed in the other clavicle of the same patient, and was cured by a single injection.

DISLOCATION BACKWARD may be caused by direct violence received upon the front of the inner end of the bone or by the forcing of the shoulder forward and inward; it may be complete or incomplete, and in the former case the displacement is also inward or inward and downward, so that the bone presses upon the trachea and œsophagus and causes dyspnea or dysphagia.

Symptoms.—The dislocation is to be recognized by the absence of the end of the bone from its normal position and its presence in its new position, which may be determined by palpation or by attention to the direction of the accessible portion of the bone. The shoulder hangs somewhat forward and inward.

Reduction is effected by drawing the shoulder outward and backward, and recurrence is prevented by maintenance of the shoulder in this position. In a number of cases in which the dislocation remained unreduced it was borne without inconvenience, but in one in which the displacement was subsequently increased by progressive distortion of the spine the interference with deglutition was such that it became necessary to excise the end of the bone.

DISLOCATION UPWARD has been caused by the forcible depression of the shoulder: in a case reported by Stokes it was gradually produced on both sides, apparently by the action of the sterno-cleido-mastoids "in forced inspiratory efforts produced by great dyspnea due to ascites." The end of the bone is displaced inward as well as upward, passing behind the sternal head of the sterno-cleido-mastoid, and resting in the episternal notch. **Reduction** is made by drawing the shoulder outward and by direct pressure on the end of

the bone. Malgaigne's hooks, devised for the treatment of fracture of the patella, have been used to prevent recurrence, one being fixed in the clavicle, the other in the front of the sternum.

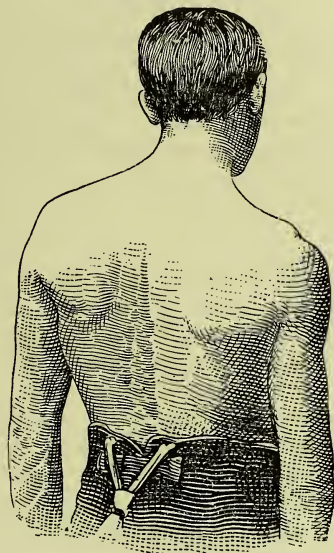
ACROMIAL END.—The common dislocation is upward or upward and outward, so that the end of the clavicle overlaps the acromion (Fig. 171). Fracture of the edge of the articular surface of either bone may accompany the dislocation. The cause is usually a blow or fall upon the shoulder.

In the great majority of cases the end of the clavicle simply rises more or less above the level of the acromion without overriding it, and can be easily pressed down into place if the arm is at the same time pressed upward; but the displacement recurs as soon as the pressure is removed. The manipulation may be accompanied by crepitus if there has been fracture of the edge of the articulation, but the injury can be readily distinguished from a fracture of the outer part of the clavicle by attention to the relations of the projecting bone to the acromion and by comparative measurements of its length. If it overrides the acromion, the overriding can be overcome by drawing the shoulder outward.

Retention of the bone in place after reduction has presented so many difficulties that some have taught that it is not worth while to attempt it, especially since the persistence of the dislocation ordinarily causes no loss of function; but the method recommended by Stimson is so simple and efficient that it should always be tried (Fig. 172). A long strip of adhesive plaster three inches wide is placed with its center under the point of the flexed elbow and its ends carried up in front of and behind the arm, crossed over the end of the clavicle, and secured to the front and back of the chest respectively while the bone is held in place by pressure upon the clavicle and elbow. Recurrence can be readily detected through the plaster by the finger or the eye. For additional security the forearm should be supported in a sling and the arm bound to the chest.

SUBACROMIAL DISLOCATION.—A few cases have been reported in which the end of the clavicle was displaced downward and engaged under the acromion, the causes being respectively direct violence upon the upper surface of the outer end of the clav-

FIG. 171.



Upward Dislocation of Acromial End of Right Clavicle (original).

FIG. 172.



Adhesive Plaster Dressing for Upward Dislocation of Acromial End of Clavicle (original).

icle, a fall upon the shoulder, and muscular action while the arm was raised. Reduction was easily made by drawing the shoulder outward, and a tendency to recurrence was observed in only one case.

SUBCORACOID DISLOCATION.—Two surgeons have reported cases of this singular dislocation, in which the clavicle is displaced forward and downward below the coracoid process, but the reports are viewed with some suspicion.

SIMULTANEOUS DISLOCATION OF BOTH ENDS OF THE CLAVICLE has been reported in about a dozen cases, the cause usually having been extreme violence by which the shoulder was pressed inward; in all the sternal end was dislocated forward, the acromial end upward.

DISLOCATIONS OF THE SHOULDER.

These are as frequent as all other dislocations taken together; they are rare in youth and old age, and much more frequent in men than in women. The frequency is readily accounted for by the formation of the joint and by its exposure to external violence.

The glenoid fossa looks forward as well as outward, and the head of the humerus in leaving it laterally passes forward and inward or backward and outward; it may also pass downward or, in very rare cases, upward. The secondary displacements succeeding to these primary ones are numerous and varied, and are commonly produced by subsequent changes in the attitude of the arm. Four principal groups may be made according to the primary displacement, and subdivided according to the points at which the head of the bone comes to rest or according to other clinical features, as follows :

Anterior	{ Subcoracoid ; very common. Intracoracoid ; exceptional. Subclavicular.
Downward	{ Subglenoid ; uncommon. Erecta ; very rare. Subtricipital. (?)
Posterior	{ Subacromial ; rare. Subspinous ; very rare.
Upward	Supraglenoid ; very rare.

In the anterior dislocations the displacement is also more or less downward (also of course inward), and in the downward ones it is usually also forward and inward, and consequently the two merge into each other without a sharp line of division; as the term is used here, the anterior include in the subcoracoid subdivision many of those known in the older terminology as subglenoid. The latter term is correspondingly restricted to include only those in which the head of the humerus lies very low.

ANTERIOR DISLOCATIONS.

These present two varieties, the *subcoracoid* and the *intracoracoid*, according to the distance to which the head of the humerus is displaced inward; an extreme form of the latter is sometimes called the *subclavicular*.

SUBCORACOID.—In this, the commonest form, the head of the humerus lies beneath the coracoid process, in contact with it or at a variable distance, a finger-breadth at the most, below it. The extent of displacement inward also varies, from just sufficient to keep the head balanced on the anterior edge of the glen-

Fig. 173—Legend should read "Double Sub-coracoid Luxation of the shoulders."

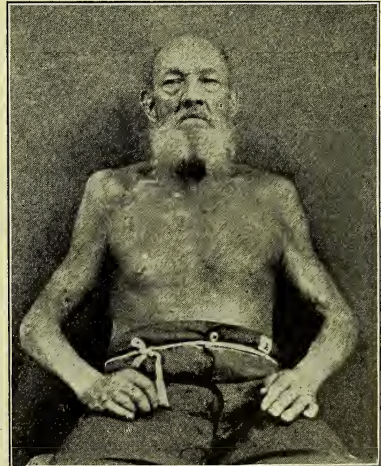
oid fossa to that in which three-fourths of the diameter of the head lies to the inner side of the coracoid process; greater displacements inward are termed *intracoracoid*.

The injury may be **caused** by direct violence, as a blow or fall upon the shoulder; indirect violence, as a fall upon the hand or the elbow; forcible abduction or outward rotation of the limb; or muscular action. Muscular action can produce a dislocation either by directly pulling the head out of its socket, as in convulsions, or, much more frequently, by imparting a sudden movement to the limb which creates conditions of leverage and impulsion similar to those of indirect violence.

The capsule is torn at its inner and lower portion, the rent extending for a greater or lesser distance along the margin of the glenoid fossa. Exceptionally, there may be no rent in the capsule. In "typical" cases the outer and upper portion of the capsule remains untorn and aids in determining the attitude of the limb and the limitation of its movements. The subscapularis muscle may be pushed inward or torn for a variable distance upward from its lower margin. The interposition of its untorn portion between the head of the humerus and the coracoid process accounts for the interval between these bones observed in some cases. The supraspinatus may be ruptured or torn from the humerus; also, but less frequently, the infraspinatus, and rarely the teres minor. Avulsion of a portion of the greater tuberosity may take the place of this rupture. The head of the humerus may rest against the edge of the glenoid fossa or farther inward against the side of the neck of the scapula; its articular surface is occasionally bruised by impact against the edge of the fossa. The tendon of the long head of the biceps is occasionally torn from its attachment, and when the greater tuberosity has been broken off it may slip to the outer side of the head.

Symptoms.—The elbow hangs a little away from the side, the outer aspect of the deltoid is flattened, and the anterior and outer fulness of the shoulder is lost (Fig. 173). Viewing the arm from in front, the axis of the humerus is seen to pass to the inner side of the glenoid fossa, and the anterior fold of the axilla is lowered. On palpation the normal bony resistance below the front and outer side of the acromion is absent, and an abnormal one is found below the coracoid process which shares in slight rotatory movements communicated to the arm. In the higher forms the head can be felt only indistinctly, if at all, in the axilla. Voluntary movements are usually lost; passively, the arm can be easily abducted, but cannot be so far adducted as to bring the hand upon the opposite shoulder and the elbow to the front of the chest. Measurement from the acromion to the elbow while the arm is abducted shows the distance to be less than on the opposite side with the arm in the same position.

FIG. 173.



Subcoracoid Dislocation of the Left Shoulder (original).

In making a **diagnosis** every effort should be used to determine the position of the head of the bone and its continuity with the shaft. In very fat patients this may be difficult or even impossible without the aid of an

anesthetic. Where there is associated fracture of the anatomical neck, a rare complication, the only means of diagnosis if the patient is fat may be the shortening of the abducted limb.

In *intracoracoid* dislocation the head of the humerus is displaced farther inward, either by the prolonged action of the dislocating violence or, more commonly, by a greater primary displacement downward by which the subscapularis is widely torn, and then on lowering the elbow the head of the humerus passes upward and inward. The rent in the capsule is correspondingly greater. In a case reported by Stimson the head of the humerus had passed below and to the inner side of the untorn subscapularis, the tendon of which thus formed an insuperable obstacle to reduction and made arthrotomy necessary.

The symptoms are similar to those of the subcoracoid form; the elbow is more widely

abducted, the deltoid more flattened, the head of the humerus easily recognizable in the subclavicular fossa. Occasionally the arm is fixed in complete horizontal abduction.

Treatment.—Reduction is usually easy, but occasionally, as in the case just mentioned, may be impossible except by operation.

FIG. 174.



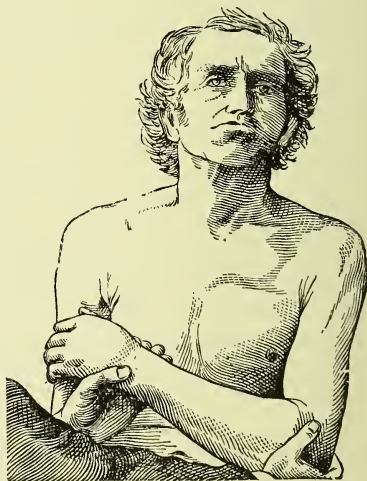
Kocher's Method of Reduction by Manipulation. First movement, outward rotation (Ceppi).

FIG. 175.



Kocher's Method of Reduction. Second movement, elevation of elbow (Ceppi).

FIG. 176.



Kocher's Method of Reduction. Third movement, inward rotation and lowering of elbow (Ceppi).

Kocher's method is very successful in the higher forms of subcoracoid dislocation, but frequently fails in the lower and in the intracoracoid. It may be employed with or without the aid of anesthesia. The elbow is flexed at a right angle and pressed closely against the side; then the forearm is turned as far as

possible away from the trunk (external rotation of the arm) (Fig. 174). Unless the head of the humerus rolls outward in front of and below the acromion during this movement, the attempt will fail. Then, while the external rotation is maintained, the elbow is carried well forward and upward (Fig. 175), the arm rotated inward, and the elbow lowered (Fig. 176). Sometimes it is useful to have an assistant press the head outward with his fingers or by a band in the axilla during the later steps.

Traction outward is also a very useful method, although it involves a certain degree of risk to the axillary vessels, especially in the aged. The patient is laid on his back on the floor, and the surgeon, seated beside him, placing one foot against his chest, seizes the arm at the elbow, and draws it steadily outward in full abduction. If this does not bring the bone into place, an assistant may press its head upward with his fingers, his thumbs resting on the acromion. Or, the patient lying on the bed, the surgeon makes traction on the arm for a few moments, and then, while maintaining the traction with one hand, swings the arm toward the side over his closed fist in the axilla. This is similar in action to the old method of the unbooted heel in the axilla, but is less dangerous.

Occasionally reduction can be made by *taking the patient unawares*. He is made to stand up, and the surgeon, standing beside him, holds his wrist,

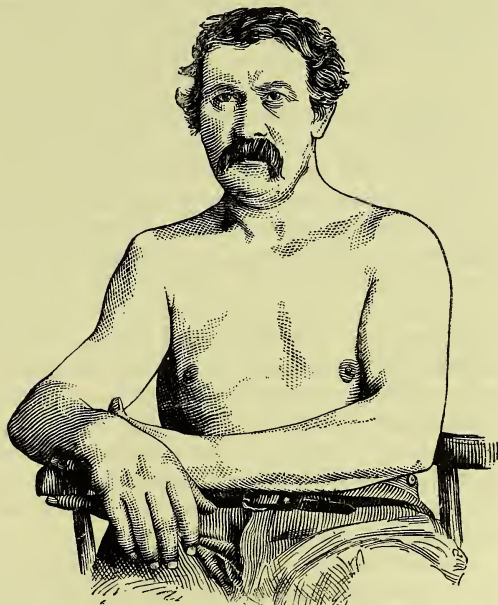
FIG. 177.

with the elbow flexed at a right angle, and gently moves the arm and engages him in conversation. Little by little the deltoid is seen to relax, and then a smart blow downward upon the fold of the elbow with quick external rotation of the arm will effect reduction in a considerable proportion of cases (Cole).

In intracoracoid dislocations traction outward should be used.

In older cases forcible rotation is needed to break up adhesions, after which Kocher's method may succeed or forcible traction may be required.

The cases in which complete reduction is prevented by the interposition of a portion of the capsule or of a tendon are very rare.



Subglenoid Dislocation (Stimson).

DOWNWARD DISLOCATIONS.

This class includes those rare ones in which the head of the humerus rests below the glenoid fossa on the tendon of the long head of the triceps, and those more common ones in which it lies somewhat higher and to the inner side under the lower and anterior edge of the glenoid fossa. The name by which they are commonly known is *subglenoid*. The class also includes a rare form, the *luxatio erecta*, and a doubtful one, the *subtricipital*.

The **cause** is forcible abduction of the arm, by which the capsule is torn

at its lower part, followed by rotation or impulsion which engages the head beyond the edge of the fossa. The lower part of the tendon of the subscapularis may be torn, and the greater tuberosity appears habitually to be in part broken off by the traction of its attached muscles.

The **symptoms** are similar to those of subcoracoid dislocation, but more marked. The elbow is abducted, the shoulder flattened, the acromion prominent, and the head of the humerus can be readily felt in the axilla (Fig. 177).

Treatment.—Theoretically, the best method of reduction would be to raise the elbow as far as possible and then to make traction, but as this involves some risk to the axillary vessels it is better to use an anesthetic and reduce by traction in moderate abduction, with direct pressure upward and outward upon the head of the humerus.

Luxatio Erecta.—In this rare form the arm is held vertically, the forearm resting on the top of the head and held there by the patient to escape the pain caused by lowering it. In the half-dozen cases reported the cause appears to have been forcible elevation of the arm. Reduction was easily made by traction upward without changing the attitude of the limb until after the head had been drawn into its socket.

Subtricipital Dislocation.—Of this only a single case has been reported. The head of the humerus was thought to have passed, after dislocation downward, backward behind the tendon of the long head of the triceps, and then to have been raised to a higher level behind the glenoid fossa by the lowering of the elbow.

POSTERIOR DISLOCATIONS.

These include two varieties, the *subacromial* and the *subspinous*, which differ only in the extent of the displacement. Some English writers make only one class and give the name *subspinous* to all. The dislocation is infrequent, and the subacromial variety is much the more frequent of the two.

The **cause** appears to be pressure of the head of the humerus outward and backward, either directly or through the elbow, aided by adduction and internal rotation of the arm.

Autopsies and experiment upon the cadaver show that the capsule is torn on its outer side and above and below, the lesser tuberosity is sometimes broken off, the supraspinatus ruptured or torn away with its facet of insertion, the *teres minor* and *triceps* are sometimes torn. In the subacromial variety the head of the humerus lies below the projecting outer portion of the acromion, with its anatomical neck resting on the outer edge of the glenoid fossa and its articular surface directed outward. In the subspinous variety the head is displaced farther backward below the spine of the scapula, and perhaps separated from it by the interposed *infraspinatus*.

Symptoms.—The arm hangs by the side in inward rotation, with the elbow directed slightly forward. The fulness of the shoulder is lost in front and increased behind. The absence of the head of the humerus in front and its presence behind can be recognized by palpation; the coracoid and the anterior part of the acromion are abnormally prominent. Voluntary movement is lost, passive motion restricted and painful.

Treatment.—Reduction appears to be easy in both recent and old cases by traction forward upon the arm or by direct pressure forward upon the head of the humerus, but recurrence is frequent, presumably because of the loss of the support of the subscapularis. When the dislocation has remained unreduced the disability has been greater than is usual in anterior dislocations.

UPWARD DISLOCATIONS.

The possibility of the occurrence of this very rare form has been proved by a few clinical cases and two autopsies. Among the causes were a fall upon the elbow, a blow downward upon the acromion while the arm was raised, and an epileptic convulsion. In one case certainly, and possibly in two others, the coracoid process was broken.

The head of the humerus lies in the interval between the acromion and the coracoid, closely in front of the clavicle and usually above its level. The arm hangs by the side, the elbow directed somewhat backward. Active and passive movements are greatly restricted (Fig. 178).

Reduction was effected in three cases by traction, and by elevation of the elbow in one, but the dislocation at once recurred in the latter. In three old cases reduction failed.



COMPLICATIONS OF DISLOCATION OF THE SHOULDER.

Compound dislocations are very rare, and are usually caused by extreme violence, which is associated with extensive laceration of the soft parts in the neighborhood of the dislocation, and inflicts other, and perhaps fatal, injuries at the same time. The wound in the skin is commonly in the axilla. The gravity of the condition arises either from associated injury done to the arteries of the axilla or from the extent of the laceration of the soft parts and the probability of suppuration. Infection is likely to take place before treatment can be begun, the extravasated blood favors its rapid spread, and the extent and irregularity of the laceration make subsequent cleansing almost impossible. Nevertheless, some very satisfactory recoveries have been reported. The **treatment** calls for the thorough antiseptic cleansing of the parts, the reduction of the dislocation, renewed cleansing, and thorough drainage of the cavity of the joint. Probably in most cases it would be best not to close the wound in the skin, but instead to pack rather deeply with the iodoform gauze for a few days. Excision of the head of the humerus may be advisable to favor drainage and oppose ankylosis.

Fractures.—These may involve any of the prominences of the humerus or scapula or the anatomical or the surgical neck of the humerus. The upper part of the greater tuberosity is sometimes, perhaps frequently, torn off by traction through its attached muscles in anterior dislocation; the periosteal attachments may persist and the displacement consequently be slight, or the piece may be entirely detached, and may even lodge in the glenoid fossa and constitute a serious obstacle to reduction. The fracture may be recognized by localized pain and crepitus and by loss or diminution of voluntary outward rotation.

The *lesser tuberosity* has been found broken off only in backward dislocation by traction through the attached subscapularis. The acromion has been broken by a blow upon it from above, which, continuing, has then dislocated the humerus downward and forward.

The *coracoid process* has been rarely broken; once certainly in connection with supracoracoid dislocation. The *glenoid fossa* is probably often broken at its edge, and the fragment may be large enough to interfere seriously with the maintenance of the humerus in its socket.

Fracture of the Anatomical or of the Surgical Neck of the Humerus.—The former is a much rarer complication than the latter: it appears to be caused after the head has left its socket by impact against the anterior edge of the glenoid fossa, which acts like a wedge along the anatomical neck and splits off the head.

It is difficult of recognition. The diagnostic points are the recognition of the head in its abnormal position beneath the coracoid process and its failure to move with the shaft, the normal or nearly normal position of the greater tuberosity, the direction of the axis of the humerus toward the glenoid fossa, and the absence of the limitation of passive movements peculiar to dislocations. Possibly crepitus may be obtained.

In fracture of the surgical neck the recognition of the dislocation is easier, because the greater tuberosity remains out of place together with the head; there is the same absence of characteristic limitation of motion and the same normal direction of the axis of the humerus; the tuberosity fails to move with the shaft, and crepitus is almost certainly to be felt.

The small almost hemispherical head may sometimes, after fracture of the anatomical neck, be pressed back into place with the fingers, and may even resume its proper relations to the shaft and reunite with it. In dislocation with fracture of the surgical neck the dislocation may sometimes be reduced under an anesthetic by direct pressure upon the head and traction on the arm. McBurney effected reduction in one case by cutting down through the deltoid upon the lower end of the upper fragment, drilling a hole in it, and inserting into this hole a strong right-angled hook, by means of which he made forcible traction and rotation upon the fragment. This failing, the choice lies between attempting reduction after the fracture has been united or establishing a false joint at the seat of fracture.

Injuries to the Blood-vessels and Nerves.—The axillary artery or one of its branches, especially the circumflex and subscapular, may be ruptured in a dislocation, but of the reported cases of such injury the majority appear to have been caused by attempts to reduce. The accident is to be recognized by the rapid extravasation of blood into the axilla and down the arm and over the chest. The radial pulse may persist, for the injury is more frequently of an arterial branch than of the artery itself. The pressure of the extravasated blood seriously interferes with the circulation, and operative interference may be required because of the persistent hemorrhage or because of the imminence of gangrene. The various methods of treatment have been pressure, ligature of the subclavian or of the axillary artery, and disarticulation at the shoulder. The resultant rate of mortality is high.

The posterior branch of the circumflex nerve appears very frequently to be bruised or stretched, with consequent temporary, or possibly permanent, loss of sensibility in the skin covering the deltoid, and of voluntary control of the deltoid muscle. It is well, before attempting reduction, to test the sensibility of the skin in the indicated region, in order that the loss of power in the deltoid when subsequently recognized shall not be wrongly attributed to the means employed in reduction.

The **after-treatment** rarely calls for more than immobilization of the joint for a fortnight and the avoidance of abduction for a week or two longer.

The **prognosis** is good in respect both of reduction and of complete restoration of function. The cases in which an uncomplicated dislocation cannot be reduced are extremely rare. The subsequent usefulness of the limb may, however, be impaired by persistent stiffness and tenderness, especially in the old and rheumatic, by paralysis of the deltoid, or by a liability to recurrence.

When the dislocation remains unreduced the arm is ordinarily fairly useful, the lost mobility of the joint being compensated for in part by increased mobility of the scapula, but occasionally it happens that the pressure of the displaced head causes so much pain or the immobility is so marked that an operation is called for to relieve it.

Treatment of Old Unreduced Dislocations.—If the dislocation cannot be reduced by the usual methods after freely breaking the adhesions by forcible rotation and traction, the surgeon has his choice between reduction by open arthrotomy and excision of the head of the humerus. The former has furnished a few good results, but it has more often proved impossible to make reduction or the usefulness of the limb has not been increased. The method of open arthrotomy is by an anterior incision. Excision of the head, through an anterior incision or through one in the axilla, relieves pressure and gives a movable joint; but, as the division of the bone is made below the tuberosities, active rotation is lost. Subcutaneous division and also open division of the periarticular tissues have been employed a few times successfully, as has also intentional fracture of the surgical neck to improve the position or to create a false joint.

Habitual dislocation, that is, the liability to recurrence of the dislocation on certain movements of the arm, has been successfully relieved in two cases by Ricard by an operation which consisted in exposing the front of the joint by an incision along the line between the deltoid and pectoralis magnus, and a second one running from the upper end of the first outward along the margin of the acromion; through this the anterior portion of the deltoid is detached and turned back. Then without opening the joint the lengthened and thinned portion of the capsule on the inner side is pinched up in a transverse fold, which is made permanent by two or three vertical silk sutures which include part of the tendon of the subscapularis below and the unchanged thick upper portion of the capsule above.

DISLOCATIONS OF THE ELBOW.

These are second in order of frequency, and are much more common in persons under twenty-five years of age than in others. They present a great variety of forms, for the radius and ulna may be displaced together backward, forward, inward, or outward, or the two bones may be displaced each in a different direction, or either may be dislocated alone, the other remaining in place. The following table is taken from Stimson:

Dislocations of the forearm (both bones) on the arm.	{	1. Dislocations backward: Backward and outward. Backward and inward.
		2. Lateral dislocations: Incomplete { inward. outward. Complete outward.
		3. Forward dislocations: Incomplete, or first degree. Complete, or second degree. With fracture of the olecranon.
		4. Divergent dislocations: Antero-posterior. Transverse.
Dislocations of the ulna alone	{	1, 2. Backward and upward. { 1. Incomplete, or first degree. 2. Complete, or second degree.
Dislocations of the radius alone	{	3. Backward and outward, behind the radius.
		1. Backward.
		2. Outward.
		3. Forward.
		4. By elongation, or the subluxation of children.
Congenital and pathological dislocations.		5. Associated with fracture of the ulna.

DISLOCATION OF BOTH BONES BACKWARD.—This is the most common of the dislocations at the elbow: two varieties, showing additional displacement inward or outward, are noted, but the variation from the displacement directly backward has no practical importance (Fig. 179).

The **cause** is usually a fall upon the outstretched hand, and the mechanism in such cases is either hyper-extension of the elbow, with the formation of an angle opening backward, or an increase of the normal outward deviation of the forearm, followed by a twist which brings the coronoid process below and then behind the humerus. The theory of dislocation by hyper-extension finds some additional support in the apparent relation between the frequency of the injury in children and the fact that in most young people the limb can be easily extended beyond the straight line. In either case, as experiment shows, the internal lateral ligament is torn, and the external one is either ruptured or torn away from the bone, perhaps retaining its connection with the periosteum, which is stripped off the back of the external condyle as the head of the radius passes backward. The capsule is torn in front, the internal epicondyle (epitrochlea) is sometimes broken off, apparently by traction exerted through the flexor muscles attached to it, and sometimes instead of this the muscular attachments are ruptured. The coronoid process is occasionally broken, as may also be a portion of the head of the radius, the cause in each case being pressure against the condyle; both fractures are rare complications, and probably occur only in cases in which the dislocation is caused by great violence while the joint is in partial flexion.

FIG. 179.



Dislocation of the Elbow Backward (Stimson).

Symptoms.—The elbow is partly flexed; the region is swollen; if the thumb and middle finger are placed on the internal and external epicondyles, and the forefinger on the olecranon, the displacement of the latter is readily recognized, and then if the head of the radius is sought for it will be found behind the external condyle as a bony prominence which rotates when the hand is pronated and supinated. Passive flexion and extension are possible within a narrow range, and in full extension abnormal lateral mobility can be recognized. If the swelling is not too great, the tendon of the triceps can be felt or seen curving backward to the olecranon when the joint is flexed. The trochlear prominence of the humerus is sometimes recognizable in the flexure of the elbow, and may be very prominent.

Treatment.—Reduction in recent cases is generally very easy, especially if the opposition of the muscles is overcome by anesthesia; it is then usually possible to slip the bones into place by pressure upon their projecting ends or by traction at the wrist. A plan that is often remarkably easy and successful without anesthesia is that in which the elbow is slightly over-extended and the bones then drawn into place by traction upon the forearm. There are cases in which the dislocation can be thus reduced and reproduced at will with the greatest ease and without causing any pain. The method by forcible flexion of the elbow about the surgeon's knee placed in the fold of the joint, while at the same time the forearm is forcibly pressed away from the arm by the knee, has been in use for centuries, and is generally successful, although theoretically

faulty. It is likely to fail whenever one or the other lateral ligament is insufficiently torn. If sufficient time has passed to have permitted the formation of strong adhesions, they must first be broken by forcible flexion, and by this manipulation it may happen that the olecranon process will be broken.

Compound dislocations are to be treated according to the principles governing in such injuries, and they often yield very satisfactory results. The choice lies between excision of the end of the humerus and reduction with ample provision for drainage. The former may be expected to give a movable but comparatively weak joint; the latter carries the greater chance of dangerous suppuration with ultimate ankylosis and a strong but stiff limb.

The *after-treatment* calls only for immobilization of the limb for about three weeks. Passive motion to prevent ankylosis is not required, and is likely to do harm; the stiffness that exists when the arm is removed from its dressings will gradually disappear under the natural use of the limb. Massage and hot and cold douches can be used with advantage at an earlier date. In children there is the chance that the irritation of the injury, and especially the stripping up of the periosteum from the humerus, may result in an abnormal production of bone that will mechanically limit the mobility of the joint; but passive motion will not prevent this result.

LATERAL DISLOCATIONS OF THE ELBOW.—The radius and ulna may be together dislocated incompletely to either side, or completely to the outer side, the coronoid process generally remaining anterior to the humerus. It would appear from the observations of some surgeons that incomplete dislocations, especially to the inner side, are tolerably frequent and often pass unrecognized, being mistaken for backward dislocation or for fracture of the humerus.

The *cause* is usually a fall upon the outstretched hand, and the mechanism appears to be an exaggeration of the outward angle of the elbow, by which the internal lateral ligament is torn and the ulna moved directly downward away from the trochlea, the radius and capitellum remaining in contact by their edges; a gliding lateral movement follows, by which the forearm is moved either inward or outward to produce one or the other form.

INCOMPLETE INWARD DISLOCATION.—The sigmoid cavity of the olecranon lies below and embraces the internal epicondyle, and the radius lies in front of and somewhat below the trochlea, the sharp inner edge of the latter being interposed between it and the coronoid process. Both lateral ligaments are torn.

The forearm is pronated and slightly flexed; its axis is parallel to and a little to the inner side of that of the arm. The olecranon and external condyle are prominent, the internal epicondyle masked, the head of the radius to be felt below and to the inner side of its normal position. Flexion and extension appear to be easy and not very painful.

Reduction is made by traction upon the extended forearm and direct lateral pressure at the elbow. In cases that have remained unreduced the usefulness of the limb appears not to have been much impaired.

INCOMPLETE OUTWARD DISLOCATION.—The radius and ulna are displaced outwardly so far that at least the central longitudinal ridge of the sigmoid cavity of the olecranon has passed beyond the outer rim of the trochlea; the radius lies partly below or entirely beyond the external condyle. Both lateral ligaments are torn, and in a considerable proportion of cases the epitrochlea is broken off, and even displaced so far downward and outward that it lodges in the groove of the trochlea. The elbow is more or less flexed, and the forearm pronated and either parallel to the arm and somewhat external to it or abducted. The internal condyle is prominent and the skin tightly stretched over it; the external condyle is masked by the projection of the

head of the radius. The olecranon is prominent, and the tendon of the triceps curves sharply backward and outward to it; the head of the radius can be easily felt (Fig. 180).

The first indication for treatment is to disengage the ridge of the sigmoid

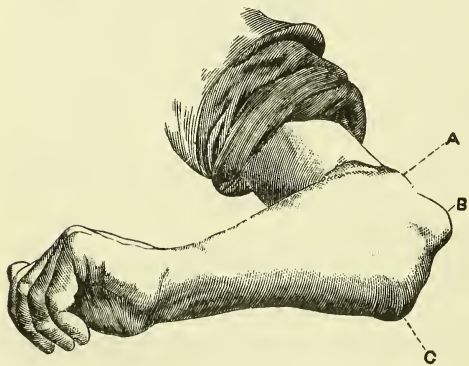
FIG. 180.



Outward (Supra-epicondylar) Dislocation of the Elbow (original).

that the anterior surface of the ulna looks inward and its sigmoid cavity embraces the outer aspect of the external condyle, the radius lying above it and in front of the supracondylar ridge.

FIG. 181.



Complete Outward Dislocation of the Elbow: A, radius; B, olecranon; C, internal condyle (Hamilton).

fossa from the groove between the trochlea and capitellum, which may be done by traction, or by hyper-extension, or by abduction of the extended forearm if the radius still rests against the external condyle so as to furnish a fulcrum; then the bones must be pushed laterally into place by pressure upon the head of the radius. If the broken epitrochlea is lodged in the groove of the trochlea, it may seriously oppose reduction, and in some cases it has prevented it.

COMPLETE OUTWARD DISLOCATION.

—There are three varieties, according to the extent of the displacement. In the first the radius and ulna are moved directly outward so far that the inner edge of the sigmoid cavity of the olecranon lies against the outer surface of the external condyle, and the radius is still farther to the outer side or has been moved upward by pronation of the forearm. In the second (sometimes called subepicondylar) the forearm is flexed and rotated inward ninety degrees, so that the anterior surface of the ulna looks inward and its sigmoid cavity embraces the outer aspect of the external condyle, the radius lying above it and in front of the supracondylar ridge. In the third (supra-epicondylar) the bones are moved still farther up along the outer border of the humerus, and sometimes also backward so that the coronoid process and the head of the radius lie behind the supinator ridge (Fig. 181).

The cause is a fall upon the hand or elbow or a blow upon the inner side of the forearm near the elbow.

The diagnosis is made by recognition of the prominent ends of the bones, the broadening of the elbow, and the direction of the bones of the forearm. In the first variety the elbow is more likely to be extended; in the two others it is flexed.

Reduction is usually easy because of the extensive laceration of the ligaments. In cases in which reduction has not been made the limb has been very useful and motion at the elbow free.

FORWARD DISLOCATION OF THE ELBOW.—Of this rare injury twenty cases have been reported, seven of which were compound, and six of these seven were further complicated by fracture of the olecranon. In most of the cases the cause was violence received upon the back of the flexed elbow. When the olecranon is broken its tip remains in place, and the ulna and radius are displaced upward upon the anterior surface of the humerus. The cases not complicated by this fracture present two varieties or degrees: first, that in which the upper end of the olecranon rests against the under surface of the humerus; second, that in which it has passed to the anterior surface of the humerus: in the latter the triceps always appears to have been torn away from the olecranon. Reduction was made in all but one of the simple cases, and in that one the nature of the injury was not recognized and the limb was amputated. Of the seven compound cases, four suppurated; two of these came to amputation, and one recovered with a stiff joint.

DIVERGENT DISLOCATION OF THE RADIUS AND ULNA.—Of this two varieties have been observed: the *antero-posterior* (11 cases), in which the ulna passed up behind, and the radius in front of, the humerus; and the *transverse* (1 case), in which the olecranon lay behind the epitrochlea and the radius on the outer aspect of the external condyle. The cause in several of the cases appears to have been forcible abduction of the forearm, by which the internal lateral ligament was ruptured, followed by internal rotation of the forearm. In two cases reduction failed, and in one, only the ulna could be replaced.

DISLOCATION OF THE ULNA ALONE.—This is very rare. The ulna is displaced backward and more or less outward behind the radius by internal rotation of the forearm upon the head of the radius as a center, and then carried upward far enough to engage the coronoid process behind the humerus by adduction of the forearm. The mode of production appears to be hyper-extension or abduction of the extended forearm until the internal lateral ligament ruptures, and then internal rotation (pronation) and adduction.

The forearm is usually in full extension and adducted; flexion is very painful, rotation free. The trochlea is prominent in front, and the olecranon is prominent behind; the head of the radius is in place.

DISLOCATIONS OF THE RADIUS ALONE.—Four forms are recognized,—backward, outward, forward, and downward; but the character of the latter is still disputed.

Backward.—The head of the radius is displaced backward, and sometimes carried a little upward behind the humerus by abduction of the forearm or by the aid of an associated fracture of the ulna or rupture of the interosseous ligament, which permits the radius to move upward independently of the ulna. The mode of its production is not understood. The orbicular ligament has been found torn, and also the external ligament at its posterior part. Reduction has been easily effected in recent cases by direct pressure forward on the head of the radius, but in some instances the interposition of the orbicular ligament has prevented reduction.

Outward.—This form is very rare, and most of the reported cases were of long standing when reported; in some of them the inner portion of the head of the radius had been broken off. The diagnosis is made by the recognition of the head of the radius outside of its normal position and of the ulna in its proper place.

Forward.—This is more common than the two preceding forms, and a not infrequent accompaniment of fracture of the shaft of the ulna by a fall upon the hand. The head of the radius is displaced forward, and perhaps upward by abduction of the forearm or by a total movement of the radius in that

direction, so that it rests, when the elbow is flexed, against the anterior surface of the external condyle above its normal position. The orbicular ligament and outer portion of the anterior ligament are torn. The limb can be abducted; full extension and flexion to a right angle are possible; supination is limited. The head of the radius can be felt in the fold of the elbow in front of its normal position. Reduction has been sometimes easy, sometimes difficult or impossible. The best method of reduction appears to be adduction of the extended forearm, followed by direct pressure upon the head of the radius. In cases of fracture of the shaft of the ulna this dislocation should always be looked for.

Downward, or Dislocation by Elongation, or Subluxation of Young Children.—This, though of frequent occurrence, is observed almost exclusively by the family practitioner or the dispensary surgeon. The theory of its nature which is most widely held is that offered by Duverney in 1751—namely, a displacement of the head of the radius downward so far that it engages under the lower border of the orbicular ligament.

The clinical history is characteristic: a child, usually under three years of age, is pulled by the hand; it cries out with pain, and refuses to use the limb, which hangs by the side, partly flexed at the elbow and pronated. There is sensitiveness on pressure over the head of the radius, and a slight interval can sometimes be felt between the latter and the condyle. Passive motion is free in every direction except supination. On forcible supination a slight click is sometimes felt, and the child at once begins to use the arm.

OLD UNREDUCED DISLOCATIONS.—The solidity of the adhesions that unite the displaced olecranon to the back of the humerus is such, and the production of new bone by the irritated and loosened periosteum in the young is so prompt, that dislocations early become irreducible by ordinary methods. If the limb is extended and stiff, the position can be improved by forcible flexion, with or without fracture of the olecranon, or resort may be had to open arthrotomy with division or removal of the obstacles, or to excision. If open arthrotomy is done, the incisions must be so planned that the adhesions on the inner and outer sides of the humerus can be divided, and the sigmoid cavity freed of the fibrous tissue which usually fills it. The choice lies between two lateral incisions and a posterior transverse or U-shaped incision, through which the triceps is divided close above the olecranon and the joint freely opened from behind; the first-named method is generally preferred.

DISLOCATIONS AT THE WRIST.

DISLOCATION OF THE LOWER RADIO-ULNAR JOINT.—By general usage the ulna is spoken of as the dislocated bone. The dislocation may be forward or backward.

In the **backward** variety the cause has been exaggerated pronation, either voluntary, as in wringing clothes, or by external violence. The end of the ulna forms a marked prominence on the back of the wrist, and sometimes overlaps the radius slightly. Reduction by direct pressure is easy.

In the **forward** variety external violence is the common cause. The ulna projects anteriorly, and sometimes overlaps the radius as in the backward variety. Reduction by direct pressure is easy.

DISLOCATION OF THE CARPUS FROM THE RADIUS.—This may take place backward or forward, and in two cases was outward; it may be complete or incomplete, and may be accompanied by fracture of the anterior or the posterior lip of the radius. The cause is forcible flexion or extension of the wrist or

direct violence. In the incomplete forms the cuneiform maintains its relations with the triangular fibro-cartilage, while the scaphoid and semilunar are displaced from the radius; in one case the semilunar remained attached to the radius, while the rest of the carpus was displaced backward.

The common Colles's fracture of the lower end of the radius was long thought to be a dislocation of the wrist backward. The differential diagnosis is to be made by attention to the position of the styloid process of the radius, to its relations with that of the ulna and with the projecting mass on the back

FIG. 182.



Diagrammatic, to indicate the deformity in (A) dislocation of the wrist backward, and (B) Colles's fracture of the radius (Stimson).

of the wrist, and with the metacarpus. Fig. 182 shows the deformity in the two injuries.

In dislocation forward the carpal bones form a rounded prominence on the front of the wrist, and the lower end of the radius presents as a sharply-defined line posteriorly, with a well-marked depression below it corresponding to the prominence in front. Reduction is easy by traction and direct pressure.

Spontaneous subluxation forward has been recently described by Madelung. It occurs gradually in adolescents or young adults, and is characterized by the absorption or arrest of growth of the anterior portion of the articular surface of the radius, with corresponding displacement forward and upward of the carpus. The end of the ulna projects markedly, and the antero-posterior diameter of the wrist is much increased; dorsal flexion is limited.

DISLOCATIONS OF THE CARPAL BONES.—A very few cases of dislocation of the second row of the carpus backward or forward from the first have been reported.

Isolated dislocation of every one of the bones of the carpus except the cuneiform has been reported. The semilunar is the one most frequently dislocated, the injury having been compound in half the cases reported, and the displacement forward in all but one.

CARPO-METACARPAL DISLOCATION.—The metacarpal bone of the thumb is the one most frequently dislocated, the displacement being usually backward and more often incomplete than complete. The cause in backward dislocation is either forcible flexion of the member or direct violence. The base of the metacarpal bone can be seen and felt as a prominence between the tendons of the extensor primi and extensor secundi internodii. *Reduction* is usually easy by direct pressure, but there is often a marked tendency to recurrence, which must be opposed by a splint or by maintaining the member in abduction and extension for one or two weeks. Dislocations forward and outward of the same bone have been observed.

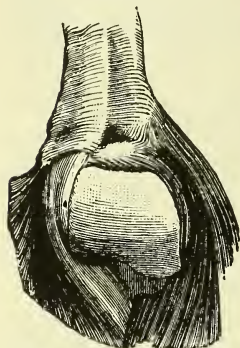
Isolated dislocations of the second and third metacarpals have also been observed, and dislocation backward of the four inner and forward of all five metacarpals.

DISLOCATIONS OF THE THUMB AND FINGERS.—Dislocation of the metacarpophalangeal joint of the thumb is quite common, and has received much atten-

tion because of the difficulty frequently experienced in reduction of the backward variety—a difficulty the cause of which is now generally believed to be the interposition of the anterior or glenoid ligament, with its included sesamoid bones.

Backward dislocation of the thumb presents three forms: incomplete, complete, and complex. The first is a form which can be voluntarily produced by many persons by contraction of the extensor of the first joint. The first phalanx moves backward and stands at a right angle to the metacarpal bone, from which position it can be returned without difficulty to its place by the action of the flexors.

FIG. 183.

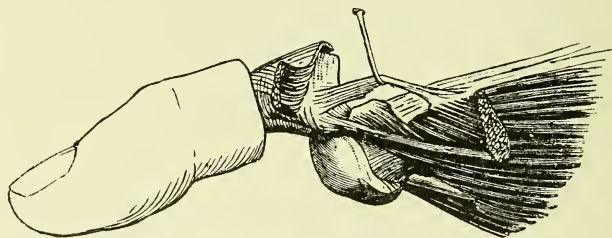


Simple Complete Dislocation of Right Thumb. The long flexor tendon is displaced to the inner side (Farabeuf).

In the *complete* form the phalanx is carried backward and upward on the dorsum of the metacarpal, usually by forced extension, the anterior ligament is torn away from the metacarpal bone and drawn backward with its sesamoid bones along, and even past, the articular surface of the head, while the tendon of the long flexor slips to one side of the head, usually the inner, although it may exceptionally remain in place, stretched along the head of the metacarpal. The first phalanx is in extension at a right angle, the terminal phalanx in flexion, the head of the metacarpal is prominent in the thenar eminence (Fig. 183).

In the *complex* form, a form produced from the complete by forced flexion of the thumb, the glenoid ligament is turned upward so as to lie between the phalanx and the head or dorsum of the metacarpal. The thumb is in straight

FIG. 184.



Complete Dislocation of the Thumb, outer side. The hook raises the periosteal continuation of the lateral ligament, exposing the reflected sesamoid bone (Farabeuf).

extension, parallel and posterior to the metacarpal; its base can be felt as a prominence behind, and the head of the metacarpal in front (Fig. 184).

The essential point in **reduction** is to avoid the transformation of the complete into the complex form. The extension must be maintained or even increased, and then the thumb should be pressed bodily downward until the anterior edge of its base overlaps the articular surface of the metacarpal, when it can be turned into place by flexion; in this way the glenoid ligament and the sesamoid bones are pushed before the phalanx. If this fails, the surgeon can sometimes succeed by combining rotation of the thumb with pressure downward, so as to free first one side and then the other—a sort of unbuttoning of the head of the metacarpal from the grasp of the glenoid ligament and the attached heads of the short flexor. In the complex form the same method must be employed, but it is necessary to use more force, so as to bring the

thumb farther downward and free the edge of the ligament which has been turned upward.

If manipulation fails, a longitudinal incision should be made, aseptically of course, on the palmar aspect of the joint, cutting directly down upon the head of the metacarpal; by drawing the edges of the incision apart the glenoid ligament is exposed, and its free edge should then be nicked at its center and lifted past the head of the bone.

In **forward** dislocation, usually due to forced flexion, the base of the phalanx lies anterior to, and perhaps a little to one side of, the head of the metacarpal, and the posterior and lateral ligaments are torn. It is recognized by the projection of the head of the metacarpal on the dorsum, and of the base of the phalanx in front. It is easily reduced by direct pressure aided by traction, or by increasing the flexion and then pressing the phalanx bodily downward as in the dorsal form.

METACARPO-PHALANGEAL DISLOCATION OF THE FINGERS.—These joints have a glenoid ligament similar to that of the thumb, and sometimes a sesamoid bone is developed in it. There is the same difficulty in reduction of the backward dislocations. It is due to the same cause and is to be met by the same measures.

DISLOCATIONS OF THE PHALANGES.—These may be forward, backward, or lateral. Reduction is usually easy, although it is possible that the thick anterior ligament may become interposed as at the metacarpal joint.

DISLOCATIONS OF THE PELVIS AND COCCYX.

The bones of the pelvis may be dislocated from each other or from the sacrum at the pubic or sacro-iliac symphysis, but the lesion is commonly associated with fracture of the pelvis, to which the reader is referred.

Dislocation of the coccyx is a rare injury, more common in women than in men, and is accompanied by symptoms of pain, disability, and nervous disturbances that are present also in cases in which there is no dislocation or fracture.

Forward dislocations have been caused by violence received upon the region of the coccyx. The pain is severe and radiates through the trunk and limbs, and is increased by any movement. The finger in the rectum recognizes the coccyx flexed forward, and if it is pressed backward into place the pain ceases. The tendency to recurrence is great, and if it is manifested the surest method of treatment would probably be to excise the bone—an operation that is very successful in the allied cases in which there is no dislocation.

DISLOCATIONS OF THE HIP.

These form, according to different statistics, from 2 to nearly 10 per cent. of all dislocations; they have been observed at all ages from six months to ninety-one and a half years, and are much more frequent in men than in women. The head of the femur may be primarily displaced in any of the four principal directions, and may undergo a number of secondary displacements. The "typical" cases, as shown by Bigelow, are those in which the Y-ligament remains untorn in whole or in part and imposes a definite attitude upon the limb. This ligament has the form of an inverted Y; the base of the Λ is attached to the anterior inferior spine of the ilium and the surface of the bone immediately external to it and above the edge of the acetabulum, and its fibers, diverging downward, form two strong bands, the inner and outer, which are

attached respectively to the inner and outer portions of the anterior intertrochanteric line.

Compound dislocations are very rare.

In the most common form the head of the femur passes backward out of the socket while the thigh is flexed, adducted, and rotated inward; if the flexion is in great part maintained, the head remains close behind the acetabulum, but if the flexion is diminished the head rises. The head may also pass directly to this higher position by leaving its socket when the thigh is but slightly flexed. The earlier writers made two classes of these two forms, calling the former "dislocation into the ischiatic notch," and the latter "dislocation upon the dorsum of the ilium," and supposed the latter to be the more frequent. Later investigations, notably those of Malgaigne and Bigelow, showed that the difference was generally due to a secondary displacement, the head most frequently leaving the socket at the lower point, and rising in the higher cases in consequence of the lowering of the knee. This has led to a general abandonment of the division, and to the grouping of all the cases as "dorsal," or "backward." The following classification, taken from Stimson, resembles that used for dislocations of the shoulder; the names of the principal classes indicate the direction of the primary displacement, and those of the varieties indicate either the place at which the head comes to rest or some marked clinical feature:

Dislocations backward	{	Dorsal, comprising the "iliac" and the "ischiatic," or those "upon the dorsum ilii" and "into the ischiatic notch" of older writers.
	{	Anterior oblique.
	{	Everted dorsal, comprising the "supraspinous" and some of the "supracotyloid."
Dislocations downward and inward	{	Obturator.
	{	Perineal.
Dislocations forward and upward	{	Suprapubic { Ilio-pectineal.
		{ Pubic.
		{ Intrapelvic.
Dislocations directly upward (supracotyloid or subspinous).		
Dislocations downward on the tuberosity of the ischium.		

BACKWARD DISLOCATIONS.

In this class the head of the femur passes over the posterior lip of the acetabulum, and lodges close behind it, or behind and above it, in the common "dorsal" form in which the limb retains the attitude of flexion, adduction, and inward rotation which it had when the dislocation occurred. Occasionally, but very rarely, the head undergoes further displacement forward and inward by outward rotation of the limb, with abduction, and extension—the "everted dorsal" variety; and Bigelow has described a still more rare variety in which outward rotation is combined with flexion and marked adduction, the head rests above the acetabulum, and the lower part of the neck lies at its upper and posterior margin—the "anterior oblique" variety.

1. DORSAL DISLOCATION.—This is by far the most common form; it includes those described as dislocations "upon the dorsum ilii," "into the sciatic notch," "iliac," "ischiatic," "dorsal," and "dorsal below the tendon" of various writers. The head of the femur leaves the joint posteriorly at a higher or lower level; it may pass below the tendon of the obturator internus, or between it and the pyriformis, or above the latter; it usually rests close to

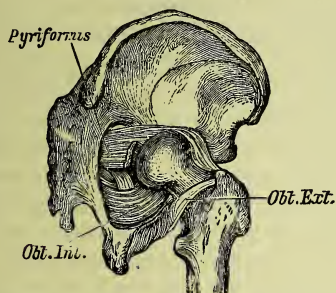
the margin of the acetabulum, seldom if ever reaching the great sciatic notch, but occasionally passing up to the dorsum of the ilium.

The **cause** is external violence acting from below upward in the direction of the long axis of the femur, and tending to push the knee toward the pelvis while the thigh is flexed, adducted, and rotated inward, or exaggerated adduction and inward rotation combined with flexion. It may be produced by transformation of a thyroid dislocation by flexion, adduction, and inward rotation.

The capsule is irregularly torn in its posterior and lower portion, and is occasionally detached from the femur, or, more rarely, from the acetabulum. In the regular or typical cases the Y-ligament is untorn. The ligamentum teres is torn away from the femur or ruptured. The quadratus femoris and the gemelli are usually ruptured, and the two obturators and the piriformis may be more or less torn.

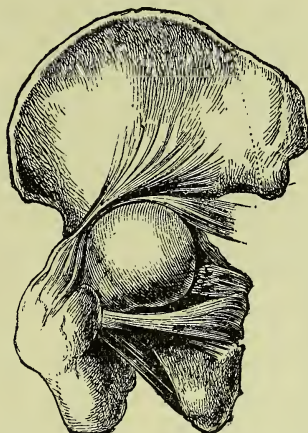
It seems to have been satisfactorily shown that in the greater number of cases the head leaves the socket at a relatively low point (the so-called ischiatic form), and then rises, as the knee is lowered, behind the obturator internus (Fig. 185), or pushes that muscle upward; less frequently it leaves the socket at a higher point (the primary iliac form) and remains in front of the obturator

FIG. 185.



Dislocation below, and then behind and above, the Obturator Internus (Stimson).

FIG. 186.



MacCormac's Specimen of Recent Dorsal Dislocation. The head of the femur lies just behind the acetabulum, below the pyriformis and above the obturator internus and the torn gemelli muscles (MacCormac).

internus (Fig. 186). The lowest point at which it has been known to lodge is the base of the spine of the ischium, the highest (possibly with rare exceptions) a point on the ilium in front of the highest part of the great sciatic notch. The edge of the acetabulum may be chipped or even extensively broken; the head of the femur has been broken once or twice.

The **symptoms** are marked: the limb is adducted, rotated inward, and more or less flexed (Fig. 187), so that its knee rests upon the front of the opposite thigh when the patient is recumbent, its toes on the dorsum of the other foot when he is upright. Flexion may be masked by the tilting of the pelvis, in which case marked lordosis of the lumbar spine can be recognized by passing the hand under the patient as he lies on his back. The upper and outer part of the thigh is broadened, the trochanter rises above a line drawn from the anterior superior spine of the ilium to the tuberosity of the ischium (Nélaton's line), and the head of the femur may be obscurely felt in the buttock.

Voluntary movements are lost, but passive flexion and adduction are possible; extension, abduction, and outward rotation impossible.

Because of its adduction the limb appears much shortened; actual shortening will be found on measurement if the other limb is symmetrically placed, but this is not usually needed to make the diagnosis. The symptoms and the whole appearance of the limb are so characteristic that the nature of the injury can hardly fail to be recognized; a much more common error is to mistake a fracture of the neck of the femur for a dislocation.

FIG. 187.



Dorsal Dislocation of the Femur (Cooper).

2. **EVERTED DORSAL DISLOCATION.**—As the name indicates, this exceptional form differs from the common one in the substitution of outward for inward rotation of the limb, a substitution that is made possible by rupture of the outer branch of the Y-ligament. If the head of the femur remains behind the socket, flexion and some adduction persist, but if it has moved upward and forward to a position near to and above the anterior inferior spine of the ilium, there will be extension and slight abduction.

3. **ANTERIOR OBLIQUE DISLOCATION.**—In this, of which there appears to be only one recorded case, the limb crosses the opposite thigh, everted, and with the knee extended.

Treatment of Backward Dislocations.—The essentials in making reduction are to relax the untorn portions of the capsule and the Y-ligament; then to bring the head of the bone, if necessary, opposite the rent in the capsule, and to lift it into place by traction or manipulation, or by abduction and outward rotation, which accomplishes the same end through the agency of the remaining ligaments. The patient is placed flat on his back, the pelvis steadied by downward pressure of the surgeon's foot or of an assistant's hand upon the anterior superior spine of the corresponding ilium; the knee is flexed at a right angle, the thigh rotated farther inward, flexed to a right angle (sometimes even beyond), and then lifted bodily upward and rotated outward and lowered in abduction. The lifting can be made easier by making a long loop of a bandage and passing it over the surgeon's shoulders and under the hollow of the patient's knee.

Or the patient may be laid on his face on a bed or table in such a way that his thighs extend beyond its margin. The sound limb is held horizontal by an assistant, and the dislocated one allowed to hang vertically down, the knee flexed, and the ankle held by the surgeon. While the surgeon gently swings the limb from side to side and diverts the patient's attention the muscles will be seen to relax, and the bone will often slip into place without further manipulation or with the aid only of a slight quick pressure downward upon the calf.

Occasionally these methods fail, the head seeming to be firmly caught by some opposing bony projection. After several failures another repetition of the attempt may instantly succeed, or traction made by an assistant in the direction of the axis of the slightly flexed and adducted thigh while the surgeon presses inward against the great trochanter may be successful. Anesthesia is a great help.

Occasionally the manipulation transforms the dislocation into a thyroid one; it can be restored to its original form by reversing the movement: flexion in abduction and outward rotation, followed by adduction and rotation inward.

The everted dorsal and anterior oblique are reduced by first converting them into the dorsal form and then treating them as such.

DISLOCATIONS DOWNWARD AND INWARD.

The head of the femur escapes at the lower or lower and inner part of the socket, and either lodges in the obturator foramen, *obturator* or *thyroid* dislocation, or passes farther inward to the perineum, *perineal* dislocation. The limb is flexed, abducted, and rotated outward.

1. **OBTURATOR DISLOCATION.**—This is commonly caused by violence received upon the back of the pelvis while the thigh is somewhat flexed and abducted, but it may be produced by forced abduction alone. As the Y-ligament is untorn and the head is displaced downward and inward, the limb is held in abduction and flexion, and cannot be extended or adducted; after flexion it can be adducted. If the patient stands upright the injured limb is held forward and appears to be lengthened in consequence of the lowering of that side of the pelvis. If a comparative measurement is made while the thighs are well flexed, shortening will be found. The trochanteric region is flattened, the adductors tense. If the patient is thin, the head of the femur may perhaps be felt on deep pressure through the adductors.

It has been stated on excellent authority that a number of patients have been able to walk immediately after the accident and have not sought treatment until after several days.

Reduction is made by flexion of the hip to a right angle, traction while making adduction, and then rotation inward while lowering the knee; further outward instead of inward rotation in the last step may also succeed.

2. **PERINEAL DISLOCATION.**—As the head of the femur in this form is displaced farther inward, the flexion and abduction of the limb are much

more marked, more so than can be together obtained in a normal limb. There is half an inch shortening, perhaps more. The cause is forcible extreme abduction, and the laceration of the soft parts must be extensive (Fig. 188).

In two cases reported by Stimson **reduction** was easily made under ether by flexion, traction, adduction, and lowering of the limb.

FIG. 188.



Perineal Dislocation of Hip (original).

DISLOCATIONS UPWARD AND FORWARD AND INWARD AND FORWARD (SUPRAPUBIC).

The head of the femur may rest upon the upper ramus of the pubes at the ilio-pectineal eminence or farther inward near the symphysis. In the latter case it is thought to have reached this position by rising from the obturator foramen, a transformation of an obturator into a suprapubic dislocation; in the former it leaves the socket at its upper and inner part by hyper-extension or abduction and outward rotation of the limb. The psoas and iliacus muscles

are stretched across the neck, and the femoral vessels are usually raised by the head.

The ilio-pectineal is the more common form; in it the limb is markedly everted and slightly abducted. The head of the femur can be readily felt in the groin. The outer and posterior aspects of the hip are flattened.

Reduction is made by traction in the axis of the limb as it lies, in order to bring the head down past the pubic ramus; then flexion while pressure is made against the head to prevent it from moving upward again; and finally rotation inward.

DISLOCATIONS DIRECTLY UPWARD (SUPRACOTYLOID).

In this form of dislocation, of which only a very few cases have been reported, the head of the femur is displaced upward and lodges below and a little to the outer side of the anterior inferior spine of the ilium. The cases are too few to permit much generalization, but it can be said that the limb is always everted and sometimes abducted; the trochanter is moved upward and backward, and the head may be felt on deep pressure. Some of the patients have been able to walk with a limp and have not sought treatment until after several days.

There is a close resemblance between these cases and those in which the head of the femur is brought above the acetabulum, but at a higher level, by adduction after a suprapubic dislocation or by eversion after a dorsal one (everted dorsal).

DISLOCATION DOWNWARD UPON THE TUBEROSITY OF THE ISCHIUM.

This form also is very rare, since the head can easily undergo secondary displacement upward and backward, transforming the dislocation into a dorsal one, or forward by abduction and eversion, transforming it into an obturator one. The limb is sharply flexed, and may be somewhat abducted and everted or inverted.

Reduction has usually been easy by traction in flexion.

COMPLICATIONS OF DISLOCATION OF THE HIP.

Compound dislocations are very rare, are produced by great violence, and are usually fatal. The complication has been observed only once in a dorsal, and two or three times each in anterior and obturator dislocations.

Injury of the femoral vessels has occurred only in suprapubic and obturator dislocations.

Fracture of the neck of the femur has occurred a number of times during attempts to reduce a dislocation. It is of much importance, for it makes reduction practically impossible, and if the fracture is at the narrow part of the neck, necrosis of the head is likely to follow. The most that can be done is to put the limb in a favorable position, or to excise the head and neck in young patients in the hope of getting a movable joint.

TREATMENT OF UNREDUCED DISLOCATIONS.

Attempts that have been made to reduce old dislocations of the hip by arthrotomy have mostly been unsuccessful, either through failure to effect reduction, through necrosis of the head of the femur, or through the death of the patient; the only successes (two cases) were obtained by the late Dr. Parkes of Chicago. Excision of the head, or of the head, neck, and trochanter, and subtrochanteric osteotomy, have been resorted to with consider-

able success in diminishing the disability. In many cases a fairly useful limb will ultimately result even without any operative interference.

PATHOLOGICAL DISLOCATIONS.

These may occur as the result of rhachitic changes in the bones, of paralysis of some of the muscles, of articular inflammations in the course of various specific fevers, and may occur even in a normal joint as the result of prolonged maintenance of the limb in flexion and adduction. It may occur gradually and painlessly, and perhaps escape observation until it is too late to remedy it.

DISLOCATION OF THE KNEE.

Dislocations of the knee are infrequent, and are divided into the *forward*, *backward*, *outward*, *inward*, and *by rotation*, occurring in that order of frequency. The dislocation is frequently compound, and often complicated by injury of the popliteal vessels, which may consist in complete rupture or in such bruising that a thrombus will form and lead to gangrene. Either popliteal nerve may also be injured. These possibilities add greatly to the gravity of the prognosis in all the severe forms of dislocation, and even the return of pulsation in the arteries at the ankle after reduction is not proof that the artery is uninjured and gangrene not to be feared.

DISLOCATION FORWARD may be complete or, more commonly, incomplete. The cause is hyper-extension of the knee or direct violence received on the front of the thigh or the back of the leg near the knee. When *complete*, the tibia lies in front of the condyles and may be displaced upward a considerable distance,—four inches in one recorded case; the laceration of the soft parts is extensive. In the *incomplete* form the articular surfaces of the tibia and femur are still partly in contact, and the laceration is much less. If the dislocation is compound, the wound in the skin is posterior and transverse. The character of the injury is readily recognized by inspection and palpation, and **reduction** is easily made by traction and direct pressure.

BACKWARD DISLOCATION may be complete or incomplete, and is most frequently due to violence received upon the front of the leg or the back of the thigh. The muscles behind the knee may be freely lacerated, and the patella is sometimes dislocated outward. The leg is usually in full extension or hyper-extension, and is sometimes deviated to one side.

Reduction is easy by traction and direct pressure. In a few cases in which reduction was not made the limb was fairly useful.

LATERAL DISLOCATIONS are much more infrequent than either the forward or the backward; they may be outward or, more rarely, inward, complete or incomplete, but the complete variety is extremely rare. The common cause of the *incomplete dislocation* is forced abduction of the leg for the outward, and forced adduction for the inward variety. The injury is recognized by the lateral projection of the head of the tibia on one side, and of the condyle of the femur on the other; the patella is usually deviated toward the side of the dislocation. **Reduction** has ordinarily been easy by traction and direct pressure. The importance of obtaining firm union of the ruptured lateral ligaments makes it advisable to keep the limb immobilized and unused for several weeks.

IN DISLOCATION BY ROTATION the leg is rotated about its long axis or about an axis parallel with it and passing through the center of one of its upper condylar surfaces. The dislocation is termed outward or inward according to the direction in which the toes are turned. In rotation about the central axis both condylar surfaces are displaced, one forward, the other backward, and the dis-

location is said to be complete; in the other form the condylar surface which corresponds to the axis of rotation remains in place, and the other is displaced forward or backward, constituting incomplete dislocation. The injury is rare, and almost all cases have been of outward rotation. Additional backward or outward displacement may be associated with the rotation. **Reduction** appears to have been easily effected.

DISLOCATION OF THE SEMILUNAR CARTILAGES.

Either semilunar cartilage may be detached at either end or peripherally, and displaced toward the intercondyloid notch or to the outside, or it may be lacerated. The injury may be produced during a dislocation or a sprain or by rotation of the leg or flexion of the knee. The internal cartilage is the one more commonly affected.

The symptoms are very like those excited by a loose cartilage in the joint: sudden, painful locking of the joint, usually occasioned by some definite movement, and recurring with greater or less frequency. Attention has been especially directed to the injury of late, and our knowledge has been increased by the data supplied by several operations undertaken for its relief. The displacement of the cartilage may sometimes be recognized by palpation along the upper articular edge of the tibia in front.

The locking of the joint can be relieved without much difficulty by various manipulations, such as extension followed by sudden flexion, rotation of the leg, or pressure upon the projecting cartilage. To prevent recurrence, various pads and braces have been recommended the object of which is either to oppose the displacement directly or to prevent the amount of flexion of the knee which is a necessary preliminary to the occurrence. The operation that has been most done of late consists in opening the joint by an incision along the side of the patella, exploration through it to determine the exact nature of the lesion, and then such treatment of the cartilage as may seem proper, usually excision of the whole or of a part, or fixation to the tibia along the peripheral border by suture.

DISLOCATIONS OF THE PATELLA.

The patella may be displaced to the outer or to the inner side, or may be more or less rotated about its longitudinal axis, "edgewise" or "vertical" dislocations, or the two forms may be combined in varying degrees (Fig. 189).

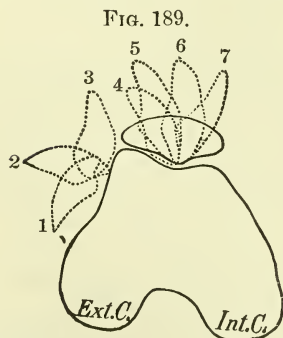


Diagram of the Various Dislocations of the Patella (Stimson).

Displacement upward or downward after rupture of the ligamentum patellæ or of the tendon of the quadriceps respectively will not be here considered as a dislocation. (See Rupture of Tendons.)

Displacement to the outer side is very much more frequent than displacement to the inner side. The causes and mode of production of the various forms are much the same, either muscular action or external violence acting directly on the patella. Gradual dislocation outward may result from hydrarthrosis of the knee or from genu valgum.

OUTWARD DISLOCATION.—This may be complete or incomplete. In *complete* outward dislocation the patella rests against the outer surface of the external condyle either by its inner border, or, more commonly, by its posterior surface, or by its anterior surface, its outer border being directed forward (Fig. 189, 1, 2, and 3). It may reach this posi-

tion either while the knee is extended or while it is flexed at about a right angle. The internal lateral ligament of the patella—*i. e.* the fibrous expansion at the attachment of the vastus internus—is ruptured longitudinally, the rent sometimes extending several inches upward into the muscle, and this may be torn away from the patella.

The nature of the injury is easily recognized, for the patella can be felt in its abnormal position: when rotation of the patella is combined with outward dislocation it may be more difficult to determine whether its outer or its inner border is directed forward.

Reduction has usually been readily made by direct pressure, after the quadriceps has been relaxed by extension of the knee and flexion of the hip. In a case seen by the writer simple extension of the knee reduced the dislocation.

Incomplete dislocations are those in which, the knee being extended, the patella rests above and partly to the outer side of the articular surface of the femur, and those habitual dislocations in which, during flexion of the knee, the patella moves outward and its outward border turns backward.

Outward Edgewise or Vertical Dislocations.—In these the patella is moved outward and turned upon its longitudinal axis in such a way that its inner border rests in the groove of the trochlea, its outer border projects forward, and its articular surface looks outward. The degree of rotation may vary from, say, 45° to 100° or 110° (Fig. 189, 4 to 7). Its fixation in this position is due to the tension of the overlying soft parts. **Reduction** has usually been effected by extension of the knee and direct pressure on the patella.

Complete reversal, the outer border passing in front to the inner side, has been reported in only two cases.

INWARD DISLOCATIONS are the same, *mutatis mutandis*, as the outward, but they are very much more rare.

CONGENITAL AND PATHOLOGICAL DISLOCATIONS.—Congenital dislocations appear to be very rare, most of the cases reported as such being actually habitual or permanent dislocations developed during infancy or childhood. The causes of these habitual dislocations are not always clear: in some the displacement seems plainly to depend upon a deformity of the limb, genu valgum, but in most it can only be said that the affection develops gradually, the patella usually slipping outward as the knee is flexed. The use of the limb is more or less interfered with by pain, and sometimes by diminution of voluntary control. The treatment consists in measures designed mechanically to oppose the occurrence of the displacement, such as a knee-cap or a splint that limits flexion. In a recent case benefit was obtained by excision of a portion of the internal lateral ligament of the patella; in another by pinching up a longitudinal fold and securing it by a continuous suture.

DISLOCATIONS OF THE FIBULA.

UPPER END.—The upper end of the fibula may be dislocated outward and forward, or backward or upward. The injury is a rare one, even if those cases are included in which it is associated with fracture of the tibia.

Outward and Forward.—In the seven reported cases the occasion has been a fall, and the production of the dislocation appears to have been associated with forcible depression and inversion of the front part of the foot, so that it has been suggested that the immediate cause was traction exerted through the extensor muscles that are attached to the front of the fibula. The displacement is easily recognized, and **reduction** is readily effected by direct pressure upon the head of the fibula.

Backward.—In three of the five reported cases the cause appears to have been the forcible contraction of the biceps. **Reduction** was generally easy, but in two the dislocation recurred, and persisted in one of them.

Upward.—There are three reported cases, but in only one of them is the diagnosis beyond question. In this one (Boyer) the patient appears to have also suffered a dislocation outward at the ankle or a lesion resembling a Pott's fracture, in which, however, the fibula instead of being broken was pushed upward. The restoration of the foot to its place corrected the upper dislocation.

LOWER END.—A very few cases have been reported in which the lower end of the fibula has been forced from its attachment to the tibia and the foot and has been dislocated backward. In a unique case observed by Stimson the lower end of the fibula had been dislocated backward from the tibia, but had preserved its connection with and its relations to the foot; the injury occurred while the patient was wrestling with another lad, and was apparently produced by forcible abduction of the front of the foot.

DISLOCATIONS OF THE FOOT.

TIBIO-TARSAL DISLOCATIONS.—Four principal groups are made, according to the direction in which the foot is displaced: *backward*, *forward*, *outward*, and *inward*.

Backward.—The cause is commonly extreme plantar flexion, by which the lateral ligaments are torn, when the liberated foot slips backward and the astragalus is fixed behind the tibia when the plantar flexion is relieved. Fracture of the external malleolus, less frequently of the internal, may coexist. Incomplete dislocation is a frequent accompaniment of Pott's fracture. The foot appears shortened in front and the heel lengthened, but if there is some swelling the dislocation may easily pass unrecognized unless a careful examination and comparison with the other foot are made.

Forward.—This form is very rare. The injury may be caused by exaggerated dorsal flexion or by direct pressure forward upon the heel. The foot appears lengthened in front, the heel shortened; the body of the astragalus can be felt in front of the tibia.

Inward.—There are two varieties: in one, by supination and adduction of the foot, the astragalus is turned down out of its mortise so that its upper articular surface lies below and in front of the external malleolus; in the other (thought to be secondary to a backward dislocation) the toes are turned more or less directly inward, the foot lying nearly or quite in the transverse plane. **Reduction** has always been easy.

Outward.—Most, if not all, of the cases described under this title appear to have been Pott's fractures, either typical or with unessential variations.

SUB-ASTRAGALOID DISLOCATIONS.

The other bones of the foot may be dislocated from the astragalus *backward*, *forward*, *outward*, or *inward and backward*. The first two forms are very rare: the outward and inward are more common, and are produced by forcible eversion and inversion of the foot respectively. Fractures of the astragalus and of the external malleolus have been observed as complications. Of 55 reported cases of all kinds (Stimson), 24 were compound. Of 24 simple cases in which reduction was attempted, it was effected in 14 and the ultimate result was good; of the remaining 10 cases and the 7 in which reduction was not attempted, secondary amputation was done in 4, and secondary excision of

the astragalus in 4; in 5 the functional result was good notwithstanding the persistence of the displacement. Of the compound cases, primary amputation was done in 3, and excision of the astragalus in 10.

DISLOCATION OF THE ASTRAGALUS.

This is a more common injury; the cause is usually a fall from a height, or forcible twisting of the foot. The varieties are very numerous: they may be grouped as *forward, backward, outward and forward, inward and forward, and by rotation*. In the first four groups more or less rotation of the astragalus about either of its axes is frequently associated.

Outward and Forward.—This is the most frequent form. The head of the astragalus rests on the outer cuneiform and the cuboid bones, or even on the fifth metatarsal, and its posterior part is still in contact with the articular surface of the tibia. The foot is adducted and inverted, the external malleolus prominent. If the dislocation is compound, the head of the astragalus presents in the wound. **Reduction** in cases not complicated by rotation of the astragalus is sometimes very easy by traction downward on the foot and pressure backward on the head of the astragalus.

Inward and Forward.—The astragalus lies in front of or below the internal malleolus, its head well depressed toward the sole; the foot is abducted and everted. Sometimes the head passes beyond the tendon of the tibialis anticus, which then tightly embraces its neck and prevents reduction.

Forward.—Only a very few cases, presenting no common features, have been reported.

Backward.—The displacement may be directly backward, or backward and to either side. Stimson has collected 16 cases, in 7 of which the bone was broken at the neck and only the posterior fragment was dislocated. The body of the astragalus can be felt behind the ankle, and the absence of its head from its normal position may be recognized. In 3 of the reported cases persistent flexion of the terminal phalanx of the great toe was present. Reduction was effected in only one-third of the simple cases.

Dislocation by Rotation.—Only those cases are here considered in which the astragalus remains in its mortise. The rotation may take place about the vertical or transverse axis (and it is then associated with more or less dislocation forward and inward, so that the separation from this class is arbitrary), or about the antero-posterior axis, without other displacement. Four cases of the latter kind have been observed and verified by direct examination, either post-mortem or during operation; in three of them the upper surface of the astragalus was directed outward; in one the bone was turned completely over, 180 degrees.

DISLOCATIONS OF THE TARSUS AND METATARSUS.

Dislocations of one or more of the other tarsal and of the metatarsal bones have been observed—namely, of the medio-tarsal joint, of every tarsal bone separately except the outer cuneiform, and of the metatarsal bones separately and in various combinations. The metatarsus as a whole has been dislocated in each of the four principal directions.

CHAPTER IX.

DISEASES AND INJURIES OF LYMPHATICS.

GENERAL CONSIDERATIONS.

THE lymphatic vessels pervade every tissue and organ in the body: the delicacy and transparency of their walls and the very close adhesion of these walls to surrounding tissues render it impossible to identify them under ordinary circumstances. In their anatomy and general properties, however, they bear a close resemblance to the veins, and the results of injuries to them and the diseases to which they are subject are analogous to those of the venous system. By reason of their function as absorbents they are the great agents of the introduction into the general circulation of the products of local septic infection. From their open mouths during the first hours following the receipt of a wound comes much of the serous flow to dispose of which drainage is necessary, and some of which, doubtless, later plays an important part in facilitating the active cell-changes upon which the healing process depends. All wounds involve lymphatics, but under ordinary conditions these vessels call for no special attention from the surgeon. Their walls collapse and become closed by the plastic exudate that is formed for the purpose of general repair. The superficial lymphatic plexuses of the skin are not only exceedingly numerous, but are also so superficially placed that they are readily influenced by antiseptic solutions applied to the surface of the skin; hence the value of external antiseptic lotions and fomentations in inflammation of the superficial lymphatics and of the somewhat deeper vessels into which they immediately empty, and the caution, likewise, with which solutions which may be toxic, as carbolic acid and corrosive sublimate, should be applied for any length of time to extensive surfaces of skin. Any consideration of the affections of the lymphatics will include those of the lymphatic glands, which are scattered along their course and form a part of the lymphatic system. In explanation of the greater frequency of affections of the lymphatic glands in youth, it must be remembered that the quantity of lymph in circulation is greater then than in later years, and that the lymphatic glands are, during that period of life, more largely developed and more active.

INJURIES OF LYMPHATICS.

Rupture of the Thoracic Duct.—This main lymph-duct, although so much protected by its anatomical position, may nevertheless, under exceptional circumstances, be wounded or ruptured. Of 17 such cases collated by *Kirchner*, 2 were due to contusions of the chest; 1 each to a puncture, a cut, and a shot wound; 3 to erosion from suppuration. In the remaining cases the account failed to assign a definite cause. The wound in these cases resulted in chylothorax in nine instances; in chylous ascites in six instances; in one (doubtful) in exudation into the mediastinum; while the remaining case was an instance of operative injury of the duct near its mouth. In a case reported by *Krabbel*, the patient on the fifth day after being run over by an empty coal-car died from suffocation due to an effusion into the right pleural cavity, which on post-mortem examination was found to be chyle and to have come from a rent in the thoracic duct opposite

the ninth dorsal vertebra, which had been transversely fractured. In one of Kirchner's cases a girl of nine years had been violently pushed against a window-sill, striking the front of her chest opposite the third rib; a gradual and increasing dyspnea developed after some days, with signs of pleural effusion, which on aspiration proved to be chyle; relief followed the aspiration, but dyspnea again became marked after some days; a proposed repetition of the aspiration was deferred on account of a spontaneous improvement which then took place; the dyspnea subsided, the signs of effusion gradually disappeared, and ultimately full health returned. Two American cases have recently been reported (Eyer, 1891; Manley, 1894). In the first a young man suffered a severe squeeze of his thorax, having been caught between a railroad-car and an engine. No bones were broken, and for some days a traumatic pneumônia of the right lung was the chief apparent result of the injury; on the seventeenth day, however, a fluctuating swelling was detected in the right inguinal region, which on being opened gave exit to much offensive gas and a foul feculent discharge. After two or three days this discharge lost its offensiveness and became opaque and milky: rapid emaciation followed, resulting in death on the thirty-eighth day from the original injury. Post-mortem examination revealed a rupture of the thoracic duct at the point where it passes through the aortic opening of the diaphragm; the escaping chyle had burrowed behind the peritoneum and had become superficial at the groin; in addition to this, some of the chyle had become diverted above the diaphragm and had dissected up the pleura from the posterior chest-wall on the right side so as to form a post-pleural cavity, filled with chyle, extending up as high as the apex of the thorax. In the second case the escaping chyle likewise burrowed behind the peritoneum and presented a superficial swelling at the groin which was incised, and gave vent for ten days to an abundant chylous discharge. The discharge then ceased, and the complete recovery of the patient followed.

There are no symptoms indicative of this rare injury until a sufficient accumulation of the escaping chyle has occurred to call for its evacuation surgically. The character of the evacuated fluid is the first indication that a wound of the thoracic duct has occurred. According to the location of the wound, the effused fluid may find its way into the peritoneal cavity or into the connective tissue behind the peritoneum, into the pleural cavity or into the connective tissue behind the pleura, or into the posterior mediastinum. The particular symptoms which the effusion will provoke must depend upon its location and extent. Rapid emaciation will result from the inanition due to the failure of the chyle-current to reach its destination.

Death from inanition is to be expected after rupture of the thoracic duct. The case already cited which recovered shows, however, that exceptions may occur, possibly due to the existence in a particular instance of a double duct or other abnormality whereby a collateral circulation is possible. Experiments on animals show that small recent wounds of the thoracic duct may heal spontaneously and quickly.

A wound of the thoracic duct is beyond surgical treatment. When, however, such a wound is demonstrated or suspected, the suggestion of Agnew is eminently rational that, instead of feeding the patient, no food should be given, in order that the walls of the duct may remain as much as possible in a state of collapse, and thus favor any attempt which nature may make toward closing the opening. Meanwhile, the possibility of introducing milk directly into the venous circulation suggests its utility as a method of nourishment during the period that must intervene before the ordinary processes of digestion and absorption can be resumed.

The **thoracic duct** may be wounded near its termination at the base of the left side of the neck in the course of operations for the removal of deep-seated growths in that region, especially when, as is sometimes the case, irregular terminal branches reach somewhat high into the neck. Keen has reported four instances of this accident. In two of these cases the fluid that exuded was unmistakably chyle; in the other two it was serous in character, but in all its abundance was great, and such as to make it extremely probable, even in the latter cases, that its source was the thoracic duct. In two of the cases the flow was controlled by a tampon, in one by a pressure forceps, and in one by a suture. Three of these cases recovered, having sustained no detriment from the injury to the thoracic duct. One died, but its fatal result was not especially influenced by the wound of the duct.

LYMPHANGITIS.—Certain areas of lymphatic radicles, or the larger continuous lymphatic trunks, may become inflamed as the result of retention within them of irritants. To the first form the term *reticular lymphangitis*, to the second the term *tubular lymphangitis*, as proposed by Bellamy, may well be applied. In the vast majority of cases the irritants in question consist of septic material absorbed from an infected wound.

Reticular lymphangitis is seen in many cases of circumscribed skin inflammation attended with more or less œdema. It is present in the condition described as "erysipeloid" by Rosenbach, a term applied by that investigator to certain patches of superficial skin inflammation which slowly spread from a point of primary infection, usually on the fingers, the point originally affected returning to a condition of health, while the inflammation extends at the periphery, until at the end of from one to three weeks the disease has exhausted itself and entirely disappears, having possibly extended over the back of the hands as far as to the wrist. Rosenbach found the cause of this affection to be the invasion of the lymphatics by a specific thread-forming, spore-bearing micro-organism derived from decomposing animal matter. Ordinary erysipelas presents a typical form of reticular lymphangitis in which the inflammation is produced by the invasion of the lymphatic channels by the streptococcus of erysipelas. (See Erysipelas, p. 65.) In the rapidly-extending inflammations which attend certain poisoned wounds the infection is propagated along the lymphatics, which share in the general inflammatory condition that prevails, both types of lymphangitis being present in a marked degree. A lymphangitis of less virulence often develops in connection with injuries of hands or feet that are neglected and subjected to motion and irritation, or with scratches and abrasions that are brought into contact with decomposing material. This inflammation may at first be limited to a small area of the immediately contiguous lymphatic rootlets; if still further aggravated, the larger trunks leading away from the part become involved, and when seated in the skin are seen as red and tender streaks running in the direction of the lymph-current.

Tubular lymphangitis is invariably the result of the entrance into the affected duct of bacteria and bacterial products of more than usual virulence. Long before the agency of pathogenic micro-organisms in its production was recognized, the affection was appreciated as of serious import and demanding active treatment to subdue it. The entrance of septic material into lymphatic channels must always attend infected wounds, but it is exceptional that a spreading inflammation of these channels results. A previously existing state of general debility upon the part of the patient predisposes to it. Frequent irritation of the infected wound and the confinement of septic secretions in it are often exciting causes. The infection of trivial

wounds, as a prick or scratch, with virulent septic material, as in dissection-wounds and snake-bites, not infrequently causes it. Cases have been recorded in which the bathing of the hands, without any wound of the skin, in putrid fluid for some time has been followed by lymphangitis. The tender and somewhat cord-like minute red streak that is formed by the inflamed lymphatic vessel results from the blocking up of its lumen by a coagulated exudate infiltrating also the ensheathing connective tissue which shares in the inflammation, this attendant cellulitis being of variable extent and intensity according to the intensity of the primary lymphatic irritation.

To the ordinary inflammatory swelling of the affected part a certain amount of oedema is added from the interruption of the lymph-current along the thrombosed lymph-vessels. The extent and persistence of this oedema will depend upon the number of the lymphatic trunks involved and the freedom of the anastomosing communications.

Inflammation of the glands into which the affected lymphatics empty speedily ensues upon a primary lymphangitis. For the production of glandular trouble it is by no means necessary that any extensive inflammation of the ducts leading from the seat of infection to the gland should exist, for infective material is often carried through the lymphatics without producing any reaction until it has become arrested in a gland, where its irritative effects are developed. Likewise a second group of glands may become involved by transmission of infection from the first, without any disturbance of the connecting ducts.

Symptoms and Course.—In addition to the local signs of lymphatic inflammation that have already been described there are present constitutional conditions dependent upon the extent and severity of the septic infection. Rigors are not uncommon. Fever, usually marked, but of variable severity, develops. The more aggravated cases rapidly display the effects of profound septicemia. When the source of irritation is less virulent and is transient or is overcome by treatment, the inflammatory reaction soon subsides, the exudate liquefies and is absorbed, and the affected vessels readily return to their normal state. If pyogenic organisms in sufficient number and activity have formed a part of the infecting virus, suppuration along the course of the inflamed vessels or in the glands into which they empty results. In this process of suppuration the surrounding connective tissue becomes invaded, resulting in abscesses. This is true both of gland suppuration and of suppuration along the course of the vessels themselves.

Diagnosis.—Superficial lymphangitis is not likely to fail of recognition. The tender red streaks indicative of the tubular variety are pathognomonic; the diffuse redness of the reticular variety, with its attendant superficial oedema and its pain, and the general fever, distinguish it from ordinary erythema or dermatitis. Some cellulitis accompanies all lymphangitis, and some lymphangitis, on the other hand, attends all cellulitis. Which is the preponderating element may sometimes be a matter of uncertainty. Practically, however, the question is an unimportant one. Phlebitis is closely related to lymphangitis in its symptoms, but a thrombosed vein forms a deeper-seated, coarser cord than a similarly affected lymph-vessel, the cutaneous redness is not so vivid, the pain is less acute, the general fever is not so intense, and the tendency to glandular involvement is less. Inflammation of the deep lymphatics is not easily differentiated from ordinary cellulitis. If in a case of deep-seated inflammation there is early involvement of the neighboring lymphatic glands; if lymphatic oedema can be detected; if patches of superficial reticular lymphangitis appear at points of anastomosis with deeper trunks,—the existence of inflammation of the deep lymphatics can be assumed.

Prognosis.—The course of a lymphangitis will depend upon the virulence the amount, and the persistence of the infective cause, and the constitutional vigor of the patient. The milder attacks upon the withdrawal of the cause and the institution of proper treatment speedily subside; when suppuration has occurred it may be limited in amount, and upon the evacuation of the abscess or abscesses a steady return to health ensues. In the more virulent forms successive groups of glands may become involved and suppurate; extensive abscesses develop; septic absorption, with or without the formation of metastatic abscesses in distant parts, imperils life; and if recovery finally takes place, it is after a prolonged illness; not rarely death from exhaustion is the inevitable end. In a certain class of cases lymphangitis assumes an insidious and chronic form, affecting large areas of vessels and producing such widespread obliteration of them as to block up permanently the flow of lymph from a considerable territory and to entail a permanent lymphœdema of the affected part. (See Elephantiasis or Lymphœdema.)

Treatment.—The recognition of the septic cause of the lymphatic inflammation at once gives direction to the treatment that is to be employed. Prompt and thorough disinfection of the original wound from which the infection has proceeded should be done. The affected limb should be put at rest and elevated. Tension, wherever present, should be relieved by free incision, without waiting for suppuration to take place. The whole affected territory should be covered with compresses kept wet with a 1 : 2000 aqueous solution of corrosive sublimate until the inflammation has fully subsided. All foci of suppuration should be freely incised, evacuated, disinfected, and drained. The constitutional treatment must be conducted in accordance with the general principles of support and elimination. Pain may require opiates, but, as a rule, all the secretions should be promoted. Stimulants and nutrients should be freely administered in the more severe cases. Persistent œdema remaining after the subsidence of the inflammation is to be overcome by bandaging and massage.

LYMPHADENITIS.—Lymphatic glands are prone to inflammation. Their function as reservoirs, to which the lymphatics hurry whatever material they gather, renders them certain to become places of arrest for whatever irritants may have gained access to the lymphatic circulation. The extent to which they become involved in attacks of lymphangitis has been mentioned in the preceding paragraphs, as well as the fact that they are affected by absorption from septic wounds without involvement of the trunks that transmit the septic matter. The amount of inflammatory reaction which they display may be of every grade from a slight transient tumefaction and tenderness to a rapid necrosis and suppuration, or to chronic enlargement and induration—according to the character of the irritant acting upon the gland and to the local and general resisting power of the individual. Syphilis, tuberculosis, carcinoma, glanders, are all characterized by specific glandular inflammation, for the peculiarities of which reference must be made to the sections devoted to these several affections.

Exposure to cold and over-exertion are often accessory causes of ordinary gland inflammation. They act as local depressants, favoring the activity of infective organisms that otherwise would have been inert. A state of general debility predisposes to glandular inflammation. The glands of the neck, axilla, and groin are more frequently affected than those of other localities, which is the natural result of the many sources of infection continually arising through affections of the mouth, throat, and extremities.

The degree of inflammation excited often falls short of suppuration, in which case either complete resolution and rapid return to the normal state occur, or, what is by no means uncommon, some induration and enlargement

of the gland persists for some time. Suppuration is a very common event. In cases of adenitis of sufficient intensity to entail suppuration, the surrounding connective tissue usually becomes involved in the inflammation and suppuration, and the resulting abscess when opened displays a pus-cavity in the connective tissue enclosing the more or less thoroughly destroyed gland.

Symptoms.—Pain, heat, and swelling are the characteristics of an inflamed gland. The swelling is nodular, and may be either well defined or diffused, according to the amount of periadenitis. The degree of heat will depend upon the intensity of the congestion. The location of the gland and the looseness of the tissue in which it is imbedded will largely determine the amount of pain attending the attack, although tenderness on pressure is always present. The constitutional reaction is likewise variable; in the more acute attacks considerable pyrexia is developed, with rigors on the occurrence of suppuration.

Distinct fluctuation may not be discernible for some time even after suppuration has begun, since the gland which is breaking down is likely to present more than one focus of suppuration, and for this reason will give at first only a boggy feeling to the touch. This, again, will be rendered indistinct by the periglandular congestion. If the surgeon waits to obtain well-defined fluctuation before deciding that suppuration has occurred, he will find it only after considerable destruction of tissue has taken place.

Treatment.—The sources of infection should be removed or receive adequate antiseptic treatment if possible. The part in which the gland is located should be kept at rest and free from irritation. From the onset of the glandular symptoms cold should be kept applied if practicable. Injections of five to ten minims of a 3 per cent. solution of carbolic acid into the substance of the inflamed gland, if made early, may suffice to prevent suppuration. If from any cause it seems best to encourage suppuration, warm fomentations may be kept applied. When pus has formed, the pus-cavity should be freely incised, all necrotic tissue should be scraped away, and the cavity after having been cleansed should be stuffed with iodoform gauze. On the third day this tampon should be removed. In many cases healthy granulating surfaces will already have formed, the adhesion of which may now be secured by the application of an absorbent compress. In other cases a more prolonged use of the iodoform tampon may be required before the desired healing surface of the cavity is produced. If sinuses have formed, they must be followed up, opened freely, and treated in the same way as the original cavity. If the healing process is sluggish, free applications of naphthaline and Peruvian balsam will serve to stimulate it, due attention being paid to the general health.

CHRONIC ADENITIS is, with rare exceptions, either tubercular or syphilitic in its nature. In the exceptional cases not referable to these specific causes nor belonging to the malignant degenerations, inunctions of iodine, blisters, and compression will be of service. Interstitial injections of a few minims of tincture of iodine, or of alcohol alone, will promote absorption. If the mass resists these measures and its presence is a cause of functional disability or a serious disfigurement, it may be excised. Very extensive operations are now often practised in the removal of tubercular glands, especially in the neck, and with great advantage. The operation should be very thorough. Every gland that can be found should be removed. The wound, if made antiseptically, usually heals in a short time, even in the most serious cases. Every measure calculated to promote the general health should be resorted to, in addition to the local means named.

LYMPHANGIECTASIS AND LYMPHANGIOMA.—The lymphatic vessels, like their congeners the veins, are subject to dilatations and varicosities, which may

be of every degree and extent. To such dilatations in general the term *lymphangiectasis* is applied, but when these dilatations by their size, their confluence, or their aggregation form distinct tumors, the term *lymphangioma* may be substituted.

Dilatations of the cutaneous lymph-radicles may be recognized as soft transparent sacs or vesicles filled with lymph, situated manifestly in the substance of the skin, and not on its surface. They occur most frequently on the inside of the thigh, on the genitals, and on the anterior wall of the abdomen, localities rich in superficial lymphatic plexuses. They are usually superficial outcroppings of a deeper, more extensive chain of lymphatic dilatations due to obstructive changes in distant trunks. Rupture of these vesicles is not infrequent, and is liable to be followed by a flow of lymph of variable amount and duration. This is known as **Lymphorrhagia**.

Rupture of a dilated lymphatic along the urinary tract and the consequent lymphorrhagia produce **Chyluria**—an intermittent accumulation of chylous lymph in the urinary bladder. Similarly the tunica vaginalis testis may be the seat of a lymphorrhagia, and **Chylocele** result.

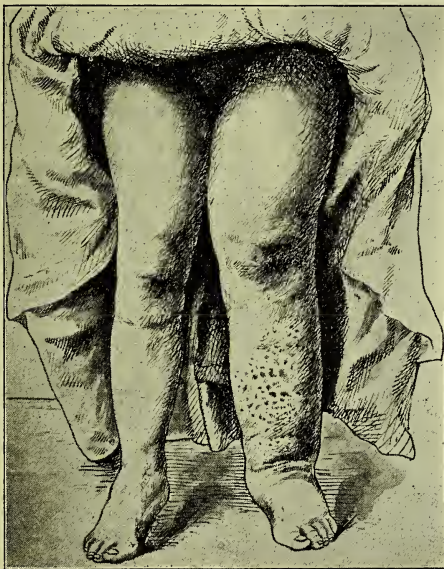
A group of dilated lymphatic radicles may be present in the shape of many closely-aggregated vesicles of varying size; or if the enlargement extends along the course of the ducts, cylindrical and tortuous cords, with nodular swellings at the site of the valve, are produced. The two varieties may coexist; or still greater dilatation at various points may have taken place, so that the varicosities are converted into cystic tumors. Such varicose swellings in the inguinal region may be confounded with herniæ. Ectasiæ or dilatations of the blood-vessels may coexist with those of the lymphatics, producing a tumor of mixed character. Such mixed growths have been noted in the tongue, producing an enlargement of it known as **Macroglossia**, and in the lips, **Macrocheilia**.

Etiology.—In a large proportion of cases of lymphatic dilatation the condition is congenital in its origin; it may be due to an essential vice of development of unknown character, or more likely to obstructions to the lymph-stream of a mechanical or an inflammatory nature arising during embryonic life. In the acquired variety inflammation and thrombosis are the chief agents which are active in the production of the condition, the direct result being dilatation of the radicles and of the primary channels, with lymph-stasis and œdema of the tissues within the area from which the narrowed or occluded vessels are supplied. Occlusion may also result from cicatricial contraction, from the presence of tumors, and from the blocking up of the lymphatic channels by tubercular or cancerous material. The presence in certain lymphatic vessels of a minute parasitic worm, the *filaria sanguinis hominis*, has been demonstrated to be the cause of lymph-thrombosis and inflammation in a large class of cases most frequently occurring in tropical regions.

Causes and Symptoms.—The cystic and tubular enlargements of the lymphatics which have been described are observable only when they are situated superficially or when they form circumscribed swellings that are distinguishable as distinct tumors. A very marked and surgically important series of symptoms may arise when in the substance of a limb or part there is a diffused dilatation with lymph-stasis. Such a condition results when there is obstruction of so large a number of the ducts converging to the root of the extremity or part that but little relief through collateral trunks is possible. The affected part becomes swollen by a hard, compact, brawny œdema, **Lymphœdema**, which is not readily reducible either by position or pressure. Attacks of diffuse lymphangitis are prone to recur, each successive attack causing an aggravation of the local condition. Thickening and induration of the skin and connective

tissue take place. Dilatation and multiplication of the blood-vessels keep pace with the general connective-tissue hypertrophy. The muscles waste. In the more advanced and aggravated cases of this class an enormous deformity results; the skin becomes coarse and hypertrophied, with a tendency to eczema and seborrhea; papillary excrescences are numerous and the development of ulcers is frequent; the swollen limb presents lobulated masses heaped up at different parts, separated from one another by deep sulci, which are especially marked at the flexures of the joints. If the scrotum is the part affected—a not uncommon occurrence—it may form a huge tumor reaching below the knees or even to the ground. This constitutes the disease known as **Elephantiasis Arabum**. While it is more common in certain intertropical countries (Barbadoes, India, Cayenne, etc.), where its frequent dependence upon the presence in the lymphatics of the *filaria sanguinis hominis* has been demonstrated, occasional instances of it are met with in all climates. The accompanying illustration (Fig. 190) shows the condition of the limb of a girl of twenty-one years of age, the subject of lymphoedema, five years after the inception of the disease. The changes in the limb were as yet moderate. The photograph from

FIG. 190.

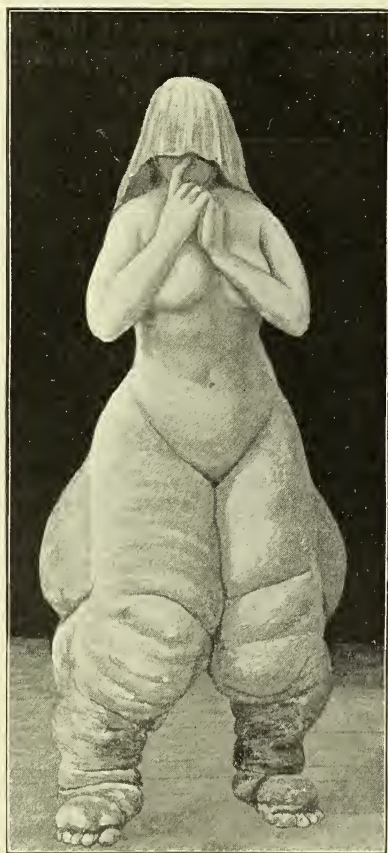


Lymphoedema of left leg five years after its onset (original).

which the cut was made was taken in 1875. At the present time, seventeen years later, the case presents the typical condition of the worst form of elephantiasis. Repeated attacks of lymphangitis have occurred during this period, each producing an aggravation of the previous condition. The leg below the knee has become enormously deformed by the production of the elephantoid masses; the outer side of the thigh remains healthy, but the skin of the inner side has developed so as to form a very large and pendent lobulated mass. A similar condition has begun to develop in the other leg, which now is about in the condition of the first as shown in the figure. Fig. 191 shows an example of the changes produced by this disease in its most aggravated form.

Treatment.—Circumscribed dilatations and isolated cystic enlargements may be extirpated with the knife. In the diffused dilatations and œdema due to persistent obstructive causes, in cases in which collateral channels may in time become sufficiently developed to relieve the stasis, relief will be given by massage, elastic bandaging, and support in an elevated position. In the absence of the possible relief of the stasis all such attempts will be fruitless. Ligation of the main artery of supply of the limb in a few recorded cases has been followed by rapid improvement. In others no benefit has resulted. A resort to it would be justifiable when other means had failed. When the disease is confined to an extremity and causes serious disability, amputation may be done. Similar tumors involving the genitals should be excised. In the latter class of cases attempts should be made to preserve the penis and testes by dissecting them out of the hypertrophied mass in which they are imbedded.

FIG. 191.



Lymphœdema in its Later Stage (original).

The chief difficulty attending the ablation of the growths is the prevention of hemorrhage; but this has been greatly facilitated by the use of the elastic bandage for constricting its base.

LYMPHADENOMA.—Under this head are to be classed lymph-gland tumors, in which the essential change is purely a hyperplasia of normal gland elements. Simple overgrowths affecting one or perhaps two or three adjacent glands, without a tendency to local degeneration or the development of constitutional cachexia, have been described, but it is probable that in most of such cases, if not in all, either foci of tubercular infection would be found in them, if a sufficiently thorough examination were made, or they would in time show themselves to be the precursors of a more generalized process.

Enlargement of lymphatic glands consisting of hyperplasia of the normal structure is an important element of leukemia. Single glands may attain the size of a man's fist in this disease, and sometimes all the lymph-glands of the body become involved. Associated with the lymphatic tumors are enlargements of other glands, notably the spleen, thymus, and liver. Changes in the marrow of the bones accompany these glandular changes. The resulting alteration in the blood—namely, the great increase of the white corpuscles and the diminution of the red—affords a

certain means of identifying this form of glandular disease, which has a place more properly in internal medicine than as a surgical affection.

MALIGNANT LYMPHOMA.—Differing from these glandular tumors of leukemia chiefly in the absence of the blood-changes are the cases of diffuse glandular enlargement to which the term **Malignant Lymphoma** (*Hodgkin's disease*, *Pseudo-leukemia*) is applicable (Pl. IX, Fig. 2). In this affection there first

appears a moderate painless swelling of one or more glands, most frequently in the neck, more rarely in the axilla, groin, or mediastinum. After a time other glands enlarge, until great tumors may result, producing much disfigurement. For a time no disturbance of the general health is observed. The glands, if removed, show simply great hyperplasia of the normal elements. Gradually groups of glands in other parts of the body become similarly enlarged, until finally almost all the glands of the body are affected. Some enlargement of the spleen may now be discernible, but it is not constant. Coincident with this generalization of the swellings the health begins to suffer; emaciation declares itself; progressive anemia develops, which, unless death from some accidental complication occurs, becomes extreme; dropsies arise; diarrhea sets in; and finally collapse and death terminate the case.

The **etiology** of malignant lymphoma is totally unknown. It attacks young adults most frequently. During its early history it is impossible to distinguish it with certainty. The element of time is required to develop its malignancy. When the swellings have become generalized and the constitutional symptoms have declared themselves, the diagnosis is plain. The characteristics of the glands of lymphoma are these: they preserve their proper shape; they do not soften and degenerate, as do tubercular glands; they do not become fused together or adherent to surrounding parts by inflammatory adhesions; they have a certain elasticity when compressed, different from the board-like hardness of unsoftened tubercular glands.

The **prognosis** is hopeless. Its course varies in its rapidity, usually extending over about one year, although a more prolonged course is not infrequent. Pressure of the enlarged glands upon the trachea, œsophagus, or important nerve-trunks may precipitate the fatal termination.

Treatment.—There is little to be gained from surgical interference except when pressure-symptoms call for relief. The internal use of arsenic, combined with its parenchymatous injection, has appeared to exercise a favorable effect on the disease in some cases; in others it has been inert. It should be tried in all cases, and pushed to the maximum of toleration. Its administration should be persevered in for a long period, and resumed whenever evidences of renewed glandular hyperplasia appear.

SARCOMA OF LYMPHATIC GLANDS, LYMPHO-SARCOMA.—A lymphatic gland may be the seat of a primary sarcoma. In the early history of such a tumor it will be impossible to distinguish it positively from other varieties of glandular hypertrophy. As it continues to develop it will, after a time, display its special malignant features as it involves the adjacent tissues and becomes attended by secondary deposits in various internal organs, as the lungs, liver, kidneys, brain, and bones. (See the chapter on Sarcoma.)

Treatment.—Soon after its development, if not already very large, it should be thoroughly extirpated, the incision going wide of the gland. If it returns, amputation should immediately be done if the tumor be on an extremity.

CHAPTER X.

SURGICAL DISEASES OF THE SKIN AND ITS APPENDAGES.

COMEDO.—This is a disease of the sebaceous glands occurring chiefly about the face, neck, chest, and back, resulting from accumulation of the altered sebum, producing small yellowish or whitish elevations marked by a central black spot, due to staining by dirt of that portion of the retained secretion occupying the orifice of the duct. Pressure will express a small plug of inspissated sebum mingled with epithelial cells, popularly called a “worm.” Partly due to idiosyncrasy, and usually a disease of puberty, it is apt to coincide with dyspepsia and constipation, and in young women with chlorosis and menstrual irregularities.

Treatment.—Frequent bathing with hot water and stimulating ointments rubbed in at night (such as sulph. præcip. ʒj to ung. aquæ rosæ ʒj), or weak alkaline ointments (such as borax, grs. xx to ʒj), may be tried. To remove the comedones apply night and morning the following paste—aceti ʒij, glycerinæ ʒiij, kaolini ʒiv,—after which gentle pressure by a watch-key applied over the spots will dislodge the plugs.

MILIUM.—This appears as small, rounded, pearly, superficial elevations in the skin, occurring chiefly on the face and genitals; they are not painful, and result from the accumulation of sebum from obliteration of a small secondary duct.

Treatment.—Each elevation must be opened, the cheesy matter squeezed out, and the interior touched with tincture of iodine or a nitrate-of-silver point.

SEBACEOUS CYSTS OR WENS.—These form variously-sized firm or somewhat soft, rounded tumors, usually seated in the skin or subcutaneous tissue of the scalp, face, back, or scrotum, although they occur elsewhere. The superjacent integument is unaltered. If injured they may inflame and ulcerate, or, in the old, degenerate into epithelioma. Although usually originating from obstruction of a duct, they often have no opening, but at times one persists, admitting a small probe. Their contents are cheesy or milky, and are often fetid.

Treatment.—Excision should be performed either by carefully dissecting out every particle of the cyst, or, after transfixing this and the overlying skin, seizing and tearing out each half of the cyst-wall with a pair of forceps.

MOLLUSCUM CONTAGIOSUM *vel* **EPITHELIALE** is characterized by small, semiglobular, or conical, whitish, sometimes translucent elevations, from the size of a pin's head to that of a pea, with a central dark spot or depression, which is the aperture of a duct. They occur chiefly upon the eyelids, cheeks, chin, neck, breast, and genitalia, and are not painful, although terminating by disintegration and sloughing of the masses. The question of contagiousness is still a mooted point. It is liable to be confounded with molluscum fibrosum, but may be distinguished from it by the absence of the central black opening in this latter affection and the more general dissemination.

Treatment.—Thorough inunctions with white precipitate or sulphur ointment will sometimes suffice; if not, each tumor should be opened, its contents squeezed out, and the cavity cauterized with nitrate of silver.

DERMATITIS VENENATA.—Tincture of arnica and the wearing of garments colored by aniline dyes containing arsenic will sometimes produce dermatitis, but it usually results from the rhus venenata or rhus toxicodendron. Owing to the volatility of the poison, actual contact with the plants is not necessary.

After a few hours or even days of incubation, in children fretfulness or slight fever may be noticed, but ordinarily the local symptoms first appear—viz. heat and itching, probably of the face and hands, with surface redness and some subcutaneous œdema. Eczematous vesicles now appear, usually first between the fingers; next the genitals are apt to be attacked in the male, whence the eruption may spread to other parts. The inflamed portions of the skin are intensely red, somewhat œdematous, and covered by groups of papules or vesicles, these latter being often confluent, while from scattered excoriations a clear, yellowish, gummy fluid exudes, forming a soft crust on drying. The eyelids, lips, nose, ears, and genitals are sometimes enormously swollen, and exude large quantities of serum. Sometimes the constitution sympathizes, as is shown by fever, coated tongue, and constipation. The burning, stinging pain is occasionally so severe as to deprive the patient of sleep, when anodynes will be required. The disease remains at its height for several days, but usually in a week the acute symptoms have subsided, although the disease may recur from time to time.

The **diagnosis**, especially from erysipelas, must depend on the history of exposure, on the appearance of the vesicles first between the fingers, next on the dorsum of the fingers and hands, finally on the palms; the eruption is more scattered than in eczema; the vesicles usually do not pass through the papular stage, as is common in eczema, but often spring directly from the skin. The disease is not contagious, although in recent cases the poison itself may be conveyed from person to person or to other parts of the same individual, as from the hands to the genitals.

Treatment.—Cloths kept wet with black-wash, provided the extent of surface be not too great, or with weak solutions of sulphate of zinc, or fluid extract of *grindelia robusta* in the proportion of ʒij–ʒiv to the pint of water, keeping the cloths just damp with the solution, are very useful; for the face, when the patient cannot remain confined to the house, equal parts of starch and precipitated carbonate of zinc may be dusted over the parts.

FURUNCLE, OR BOIL.—This is a disease, probably due to microbic infection, in which one or more small, circumscribed, acuminate, dusky-red, firm, painful spots form in the skin, the result of localized inflammation, the central portion of skin dying, forming a slough or “core” around which suppuration takes place, ending in the separation of the “core,” the subsidence of the inflammation, and the healing of the cavity by granulation. The maturation of each boil takes about a week or ten days; sometimes no suppuration occurs, when the condition is called a “blind boil.” The pain is throbbing, and often quite severe until suppuration and loosening of the slough have occurred, when it subsides. Although any portion of the integument may be attacked, the face, ears, neck, back, axilla, buttocks, perineum, scrotum, labia, and legs are the favorite sites; the nearest lymph-glands may become enlarged, and sometimes constitutional disturbance results. Erroneous hygiene and diet even in the robust, overwork, nervous depression, improper food, irregularity of the bodily functions, and certain atmospheric conditions prevalent in spring and autumn are predisposing causes. The differences from carbuncle, with which alone a boil is likely to be confounded, will become clear when the former disease is described.

Treatment.—The cause should be ascertained and removed. The diet must be regulated and varied. Exercise in the open air, quinine, iron, and strychnine are useful in debilitated patients. Arsenic, with or without iron, is at times of benefit. The sulphite or hyposulphite of sodium, grs. xv–xxx every three hours, sulphide of calcium, $\frac{1}{8}$ gr. every two or three hours, and

proper doses of sulphur internally have been thought to do good at times, but there is no specific. When a hair occupies the center of the boil its avulsion will sometimes abort the furuncle. Locally a 10 per cent. salicylic-acid ointment, or ichthyol combined with an equal quantity of collodion, will prove beneficial. White has reported a series of cases of furunculosis in which the obstinate recurrence of boils was arrested by the administration of bichloride of mercury in full doses. It is possible that this acts through its bactericidal properties, the origin of the condition being perhaps microbic.

CARBUNCLE.—This is a circumscribed, deep-seated inflammation of the skin and subcutaneous tissue, terminating in a slough. Constitutional disturbance is usually marked, the disease being ushered in by a chill followed by fever. The skin becomes hot, painful, and dusky red, and a flattened, fairly circumscribed inflammatory induration of the subcutaneous tissue forms; the pain is usually burning. Steadily progressing and extending, until it may be from three to six inches in diameter, by the end of from ten days to two weeks the mass begins to soften, and the skin ulcerates at numerous points, which are usually filled with yellow sloughs, whence issues sanious pus. The sieve-like appearance presented by the skin surface, due according to Warren to pus in the columnæ adiposæ, is characteristic, but in most large carbuncles the overlying integument sloughs away sooner or later, leaving a large, slowly-healing ulcer. Carbuncle lasts for from four to six weeks, is usually single, and its favorite sites are the back of the neck, shoulders, back, and buttocks: it is especially dangerous when occurring on the scalp, abdomen, and upper lip; in these locations, occurring as it does in the young, it runs an acute course and is apt to terminate fatally from pyemia. It is a serious disease when extensive and attacking the elderly, especially if complicated with Bright's disease or diabetes, which latter affection stands in a causative relation to it. The causes, other than diabetes, are probably the same as those of boil. The possibility of microbic origin should be remembered. The size, flatness, multiple points of suppuration, and extensive slough distinguish carbuncle from furuncle.

Treatment.—Large amounts of easily digestible, nourishing food should be given, but stimulants only when distinctly indicated. Quinine and tincture of iron in large doses, with anodynes to procure rest, are requisite. Different plans of local treatment may be adopted: one, of doubtful utility, is compression by the concentric application of adhesive straps, limiting the spread of the inflammatory exudates and seeming to lessen the destruction of cellular tissue; another and far better plan is applicable even in the early stages, before the skin is seriously damaged, and consists in making under anesthesia multiple crucial incisions or one long incision—after freezing the parts to render them friable—and thoroughly curetting away all dead or dying cellular tissue, carefully disinfecting, suturing, and draining, as in an incised wound. This is done upon the theory that the spread of the disease is due to the micro-organisms flourishing in the sloughs. Or warm moist antiseptic dressings covered with oiled silk, early removal of loose sloughs, and the free use of iodoform may be employed, but poultices should be avoided.

BURNS AND SCALDS.—These two classes of injuries may be conveniently discussed together. Scalds are apt to be more extensive, because the clothing diffuses the fluid over a greater area and the hairs remain, while in burns these are destroyed and the tissues are often more deeply involved; the effects of concentrated acids and alkalies resemble burns rather than scalds. The old classification of Dupuytren needs revision since the introduction of modern methods of wound-dressing, so far as prognosis goes, although if asepsis is not secured and maintained, in the more severe cases the old rules will still hold

good: moreover, the ability rapidly to remove the drain of free suppuration and relieve pain by Thiersch's method of skin-grafting lessens the secondary mortality of extensive burns or scalds. For practical purposes only three classes of burns and scalds need be made, viz.: (1) those presenting erythematous inflammation of the skin without vesication; (2) those in which the inflammation of the skin results in the formation of vesicles and bullæ; (3) those in which partial or complete carbonization of the part results, or in which from the secondary effects of inflammation more or less extensive and deep sloughs form.

Death, when it occurs, results early from shock; after reaction, from congestion of internal organs produced by reflex vaso-motor paresis, or from these congestions going on to actual inflammation of the pulmonary or gastro-intestinal mucous membrane, of the serous membranes, etc.; after suppuration is established, exhaustion, erysipelas, pyemia, septicemia, and tetanus may end life. Œdema of the glottis from scalds of the mouth is a very fatal complication, while perforating ulcer of the duodenum sometimes occurs.

The **prognosis** depends upon the extent and depth of the injury; thus mere reddening of two-thirds of the cutaneous surface will almost inevitably result in death, while destruction of one-third of the skin will probably produce the same result; yet most burns of the first and second classes of the extent commonly met with in practice will recover; in burns of the third class the region affected, the depth to which the tissues are destroyed, the age, sex, and previous health of the patient, will determine the result; thus even slight burns of the third degree may be fatal to the young or old.

Symptoms.—These are local and constitutional. The local vary with the depth of the injury, from mere reddening and swelling, up through vesication, excoriation, and partial destruction, to charring. The pain may be of every grade, from moderate burning up to intense agony, the most painful variety of burns being that in which the outer layers of the skin are destroyed, exposing the nerve-endings, less pain being complained of when total destruction of the skin has taken place. The constitutional symptoms vary from slight fever in burns of the first class to profound shock in the deeper forms, followed by reaction, and this succeeded by congestion or inflammation of some one or of many of the viscera. Thus death may result from cerebral coma; later, the exhaustion incident to suppuration, pain, or hemorrhage, with the inflammation of the kidneys or nervous centers liable to set in at this stage, is apt to carry off the patient.

Local Treatment.—In slight or moderate burns and sunburn nothing else relieves the pain so well as wrapping the part in cloths wet with a saturated solution of bicarbonate of sodium or ordinary "baking soda," or a weak dilution, 1 : 8, of phénol sodique.

In severe burns remove the clothing with great care, lest the cuticle be torn off; relieve the tension in the blisters by pricking them with a needle; avoid exposure to cold during the removal of the clothing and during the after-dressing; disinfect the parts with warm boric acid or boro-salicylic lotions; dress the parts so as to exclude the air and keep them antiseptic by boric acid, iodoform—in reasonable amounts—oil of eucalyptus, or other non-poisonous drugs, and by enveloping the parts in cotton rendered aseptic by prolonged heating. Subsequent dressing should be done only when absolutely necessary on account of the pain, the sloughs being carefully removed or trimmed away, and the most unirritative germicidal solutions employed for cleansing the surfaces. Where destruction of tissue has occurred, splints, elastic traction, and position must be employed to prevent or overcome cicatricial contraction, while early attention must be paid to the condition of the granulations, with free skin-grafting—

either from human sources or from the lower animals—after Thiersch's method. Weak solutions of sulphate of copper, or of chloral, grs. x–3j, to stimulate the formation of granulations, and repression of the same by the solid nitrate of silver and pressure when flabby or redundant, will suffice in many cases to ensure healing, and should precede skin-grafting when this is indicated.

Constitutional Treatment.—If shock is severe, stimulants, such as ammonia and alcohol, with warm coverings, hot bottles, etc., and opium internally, should be used; later, fluid nourishment, regulation of the bowels and of the cutaneous and renal secretions, with iron, quinine, and treatment calculated to support the system under the drain of prolonged suppuration, and treating such complications as pneumonia, pleurisy, peritonitis, enteritis, or hemorrhage on general principles, constitute all that can be done.

The scars resulting from burns and scalds are almost certain to contract more or less for a long time afterward, and produce in bad cases most terrible deformities. These are to be prevented as far as possible by position, splints, active and passive motion, etc., and later by operative measures. (See Orthopedic Surgery, Surgery of the Face, and Plastic Surgery.)

LIGHTNING-STROKE.—Instantaneous death or only temporary unconsciousness may result. Sometimes superficial or deep burns, or paralysis of the special nerves or of those of general sensation and motion, may be occasioned.

Treatment.—The application of external warmth, artificial respiration, and stimulants are indicated during the stage of shock; later, galvanism and strychnia internally may aid in the restoration of the paralyzed nerves. The local lesions must be treated in the same manner as burns of the same class.

FROST-BITE.—This term is used to designate the local results of cold, the destructive effects being either direct or more usually indirect from inflammation. The depressing effect of cold upon the circulation of the part is such that this ceases, and the part may be actually frozen. With due care the vitality may yet be restored; but even when actual congelation of the part has not occurred, unskilful treatment will determine gangrene.

Symptoms.—First numbness and tingling, then loss of power, usually commencing in the fingers and toes, and a sense of weight, are complained of; finally, absolute loss of sensation is noted, and the parts are bleached, white, and icy cold to the touch. Those parts which are hopelessly frozen, at first white, cold, and insensible, after reaction either become swollen and discolored, or may shrivel up and contract. Gangrene does not usually set in for some little time, it being not unusual for the parts to look quite well for some days, then to become discolored, bluish, next dark-blue, and finally black. A line of demarcation forms, evidenced by inflammation in the contiguous living tissues, and then a line of separation—*i. e.* ulceration—sets in, resulting eventually in the separation of the dead tissues.

Treatment.—As the result to be dreaded is partial or total death of tissues the vitality of which has been seriously lowered by cold, and as undue reaction will either determine the immediate death of the parts or give rise to such a degree of inflammation as will destroy them by the compression exerted by the exudates upon the feeble circulation, the indication is clear—*viz. gradually* to induce a return of the heat-producing power of the parts. The transition must be slowly progressive; thus, gently rubbing the parts with snow or employing friction while they are immersed in iced water is advisable, this being done in a room where the temperature is low; even the warmth of the bed has been known to set up inflammation, which tends, as has been shown, to run on into gangrene. Of course anything like approach to a fire must be avoided. As soon as the general bodily temperature and that of the part have become about

normal, stimulating friction with soap-liniment, alcohol, and water or spirit of camphor, with elevation of the parts, should be tried, after which, the air of the room having been gradually warmed, exposure to the air for a time is advisable; then cover the parts with cotton: as reaction progresses, stimulants and warm drinks may be cautiously administered. If excessive reaction takes place, evaporating lotions of equal parts of alcohol and water are indicated. Should gangrene set in, the treatment must be such as is proper for this condition.

CONSTITUTIONAL EFFECTS OF COLD.—This is first stimulating, the circulation being increased in force and frequency; then pain and uneasiness supervene; general numbness and coldness, with drowsiness, inducing an almost irresistible desire to sleep, are finally experienced, which if yielded to means death from congestion of the viscera, the slowing respiration and failing nervous power and circulation making up a complexus of symptoms like those of apoplexy. Sudden chilling produces death by cerebral anemia, slow prolonged exposure to cold kills by cerebral congestion, while sudden exposure to warmth produces a fatal result from embolism; partial freezing usually causes fatal congestion or sometimes anemia, both induced by capillary embolism.

Treatment.—In addition to the local means advised to prevent sudden reaction, artificial respiration should be tried, and the temperature of the apartment must be raised even more gradually than when dealing merely with a frozen member.

CHILBLAIN OR PERNIO.—This results from the sudden application of cold to any exposed part, as the nose, ears, lips, fingers, or toes, of debilitated persons. Moderate exposure to dry cold, or even to cold, damp air, followed by the sudden increase of temperature induced by approach to the fire, is a prolific cause of the slighter forms, especially in children and those with feeble circulation.

Symptoms.—These may be only a slight degree of redness, swelling, heat, and itching, which subside almost without treatment; or a more severe condition may exist, marked by considerable swelling, such deep congestion as often to produce a bluish tinge of the skin and very annoying heat, pain, and itching. Although usually a favorable termination is to be expected, cases occur where the inflammation runs higher, and vesicles form, which rupture and leave obstinate ulcerations. If neglected, these ulcers may degenerate into foul sores, even the bones becoming bared and carious; but such results are decidedly exceptional, the variety characterized by slight local congestion, tenderness, and itching being that usually seen.

Treatment.—This should be prophylactic as well as curative. Persons once attacked are liable to relapses upon slight provocation. Warm woollen socks, gloves, and proper mufflers for the ears and face should be worn. As a feeble circulation favors pernio, frictions of the parts to stimulate the circulation, with general tonics, are advisable. Avoid any sudden approach to the fire after exposure to cold. In mild acute chilblains gentle frictions with snow and the application of iced water, with rest and the use of lead-water and laudanum, usually suffice. In the more chronic forms, when the skin is unbroken, stimulant and astringent applications to the locally sluggish circulation, such as tincture of iodine, alcohol, camphorated soap-liniment, oil of turpentine, oil of peppermint pure or diluted up to even six parts of glycerin, and numerous other similar applications, have all been successfully employed; in especially chronic or recurring cases the constant galvanic current has proved serviceable. When ulcers form they must be treated upon general principles.

CALLOSITIES.—These are flattened, irregular, translucent, yellowish, dense

thickenings of the cuticle, which are developed by prolonged pressure and friction, and are usually seated over bony prominences. According to their situation and cause their appearance varies; thus various mechanical trades will show thickenings on the hands differing in situation and appearance. The soles and sides of the feet are common situations. So long as the exciting cause persists, the thickening will remain, but usually when this has ceased to act for a considerable time they gradually disappear, either exfoliating *en masse* or more gradually desquamating. The only troubles to which they give rise, beyond slight diminution in sensibility and freedom of movement of the parts, are the tendency to form fissures over the flexures of the joints, and the occasional excitation of pain, heat, and suppurative inflammation from irritation of the subjacent tissues.

Treatment.—Except in the event of the last two contingencies, treatment is rarely needed. For fissures the application of softening ointments, as diachylon spread upon lint, unirritating warm antiseptic washes or fomentations, and quiet of the parts if the cracks be deep, secured by firm coaptating strapping with adhesive plaster, are usually sufficient; if abscess forms, treat it as such.

CLAVUS, OR CORN.—A corn is a circular, flattened, hemispherical, circumscribed thickening of the horny layer of the epidermis, extending in the form of a cone below the normal level of the corium, constant pressure having produced some localized absorption of this structure. Corns result from pressure or friction either of the shoes or of adjacent surfaces, as those of contiguous toes; in the latter situations, from the constant moisture, the usually yellow, horny, epithelial masses being substituted by soft, whitish collections of epithelium (soft corns), which, being removed, leave a slightly elevated margin of white, sodden cuticle with a central reddened depression—*i. e.* the deepest layers of the epidermis—through which is seen the congested corium. Pressure always produces pain by driving the conical mass of epithelium down upon the sensitive corium, while, from constant irritation, inflammation and even supuration are not uncommon.

Treatment.—Since pressure from improperly-shaped shoes is the usual cause, these must be improved in form, pressure must be taken off by felt rings, and after prolonged soaking in warm water containing washing-soda the outer layers of the corn should be gently scraped away with a sharp knife—this is better than digging them out with the point; the tender surface should be protected by a little patch of salicylic rubber plaster. Or the reverse process may be employed—*i. e.* hardening by applications of tincture of iodine or nitrate of silver at night, and in the morning removing with the knife the hardened tissue. The following prescription, painted on at night and scraped off in the morning, is excellent:

Ry Acid. salicylici,	ʒiiss ;
Ext. cannabis indicæ,	grs. x ;
Collodii,	ʒj.
M. Sig.—Paint on daily.	

Soft corns should have the softened epithelium gently removed, and be desiccated by keeping the surfaces separated, at the same time removing pressure by proper disposition of pads of absorbent cotton, preceded by free dusting with equal parts of boric acid and oxide of zinc. Inflamed corns must be treated by rest, and warm, moist antiseptic dressings, the pus being let out when formed, remembering that in the old, in whom senile vascular changes have occurred, erysipelas and gangrene not infrequently result from trimming a corn too closely.

HORNS (CORNU CUTANEUM).—These are solid, wrinkled, dry, hypertrophic outgrowths of the skin; they may be twisted, elongated, flattened, or mushroom-shaped, and are brownish-yellow, gray, or black in color. They vary from the size of a mustard-seed to several inches in length, may be single or more rarely multiple, have flattened or concave bases attached to normal or inflamed skin, and, while found on any part of the body, are most common upon the face. Elderly persons are most liable to this affection, the young being rarely attacked. Of slow growth, and painless unless injured, they sometimes drop off, a new horn springing from the shallow ulcerated base. In structure they consist of hyperplasia and cornification of the epidermic cells, with hypertrophy of the papillæ; or, again, they may spring from the interior of a sebaceous gland, an old ulcerated sebaceous cyst being often their starting-point. Warty growths may also be the origin of horns, and the bases of all forms may undergo epitheliomatous degeneration.

Treatment.—Owing to their tendency to re-form, the base from which they spring must be freely dissected out, or destroyed by chloride of zinc, caustic potassa, or the thermo-cautery.

WARTS (VERRUCÆ).—Warts are circumscribed, elevated hypertrophies of both the papillary and epidermic layers of the skin. The common variety (*V. vulgaris*) most commonly appears upon the hands of children, but may occur on other parts and at any age, forming flattened or semiglobular projections, varying in size from that of a pin-head to half an inch in diameter. Primarily of the same color as the surrounding skin, they become darker and harder after a time, and the elongated papillæ, covered with cornified epithelial cells at first, may become partially denuded of these and present the appearance of a number of projecting points, with a circumvallation of thickened cuticle: this is popularly termed a "seed-wart." Warts may be single or multiple, may rapidly attain their full size, may last indefinitely or spontaneously disappear at any stage, and are not contagious: if picked or wounded, they bleed freely, being often very vascular. The *filiform wart*, occurring in narrow lines along the free edges of the nails or elsewhere in patches, is formed by excessive elongation of the papillæ, without the surrounding epidermic rim of the ordinary form. The flat wart (*V. plana*) is never much raised above the surface, retains its outer layer of epidermis, and therefore possesses a smooth surface. Warts may occur upon the scalp singly or in small numbers, and consist of numerous projections, compressed at their bases, but standing out at the periphery; they are often very vascular. Anatomically they consist of hyperplasia of the papillæ, of the blood-vessels, and of both the rete and the horny layer of the epidermis. A form appearing congenitally, or even later in life, apt to be pigmented and to become hairy, is called *nævus verrucosus*. When such pigmented hairy growths occupy considerable portions of the surface and coincide with the courses of important cutaneous nerves, they are called *papilloma neuroticum*, and cause great disfigurement.

Treatment.—Painting the growths with the juice of the milk-weed, with tincture of iodine, or with a solution of perchloride of iron, or applying moistened powdered chloride of ammonium, will often cause their disappearance. If these means fail, or if time is an element, free painting with bichloride of mercury, gr. xxx to fʒj of collodion, touching once or twice with one of the strong mineral acids, or repeated applications of glacial acetic acid, may be resorted to: care must be exercised when employing any of these agents over superficial joints, lest they penetrate too deeply. Excision by the knife, snipping them off with curved scissors, or curetting them away when soft, is of course the quickest means of removing warts. Hypodermatic injections of cocaine will avoid pain.

DISEASES OF THE NAILS.

Although chronic inflammatory affections of the neighboring skin often produce changes in the form, color, and thickness of the nails, these so rarely call for surgical interference that they will not be described here.

HYPERTROPHY.—This can result only from hyperplasia of the papillæ of the matrix, the thickening of the nail occurring at the base, front, lateral edges, or over its whole extent, according to the parts diseased. The nail may be evenly thickened or variously curved or twisted, while its structure becomes brittle, opaque, and discolored. Removal of the most projecting portions of the nail will reveal the papillæ elevated far above the normal level of the matrix. The change is slow, progressive, and when pronounced is usually permanent. The causes are not well understood: pressure, however, seems to be an exciting cause, this being more efficient in the nails of the toes, especially those of the great and little toes. The old, whose epithelial structures tend to overgrowth, are more liable to hypertrophy of the nails than the young. When attacking the fingers, beyond the blunting of the tactile sensibility and the deformity, no special trouble arises, unless painful cracks form from the splitting of the brittle nails. When affecting the feet, however, it is difficult for the patient to wear shoes, the pressure leading to inflammation of the adjacent soft parts. It is thought that mere abnormal broadening of the nail is one of the causes of "ingrowing toe-nail."

Treatment.—When the deformity seriously interferes with the appearance or use of the foot, the nails must be reduced to normal dimensions by strong scissors, with the knife or a fine saw, removing at the same time as deeply as possible the elongated papillæ, which may be cut across during the operation, and then cauterizing with perchloride of iron. When lateral hypertrophy without thickening or incurvation is present, before inflammation has been excited, frequent trimming of the anterior margins and corners of the nail has been recommended. When actual ulceration of the lateral fold has occurred, removal of an elliptical portion of the hypertrophied fold, suturing of the wound, removal of a strip of nail, including the matrix underlying it, followed by the use of wide-toed shoes, are the measures best adapted to cure the disease. Thinning the nail by scraping a groove with a piece of glass, and packing a little cotton beneath the buried edge of the nail, if persevered in, aided by repression of the granulations by dusting with nitrate of lead, touching with nitrate of silver, etc., will eventuate in the cure of a certain number of cases.

INFLAMMATION OF THE MATRIX (ONYCHIA).—As a result of traumatism in unhealthy individuals inflammation and suppuration sometimes occur at the root of a finger-nail and in the contiguous portion of matrix ("run-around"), and often stubbornly continue unless the loosened, sharp edge of the buried nail be carefully trimmed away from time to time and a little iodoform cotton be employed to press back the inflamed tissues. From lateral hypertrophy of a toe-nail the sharp lateral edge of the nail becomes imbedded in the lateral fold, or from improper lateral compression of the toes the same portion of soft tissues is forced up against the margin of the nail, in either case causing inflammation, suppuration, and ulceration, resulting in the formation of red, exuberant, excessively painful granulations, constituting the condition called **ingrowing toe-nail**, though more correctly, in most instances, it should be termed "up-growing pulp." Sometimes both edges, or even the whole matrix, become involved, producing pain on any movement of the member. When inflammation and ulceration of the whole matrix occur, especially where a finger is involved, the condition is termed "**onychia maligna**:" it attacks only those in depressed health.

Treatment.—The treatment suggested for hypertrophy of the nail is indicated for all inflammation of the matrix, so far as removal of the portion of nail producing irritation is concerned, but in onychia maligna the whole nail usually requires removal under anesthesia, with destruction of the matrix by caustics, or, better, dressing with powdered nitrate of lead or iodoform, and the internal administration of iodide of iron, cod-liver oil, etc.

TUMORS OF CICATRICES.

HYPERTROPHIED SCARS.—Commonly these are masses of dense fibrous tissue resulting from prolonged cicatrization due to extensive losses of substance. Hypertrophied scars assume a nodular, stellate, and reticular band or bridle form, either by the time cicatrization is completed or shortly afterward from further contraction; or, again, long subsequently to the healing, apparently normal, non-elevated scars take on this hypertrophic process, resulting in the formation of tumors presenting the most varied appearance. No cause can be assigned for these secondary fibroid alterations of scars, which sometimes attack those resulting from small linear incisions. The condition differs from keloid chiefly in the disarrangement of the component bundles of fibrous tissue and the entire absence of the papillary layer of the skin. The vascular supply, free at the outset, diminishes as the scar contracts.

Treatment.—Excision, followed by a plastic operation, is all that can be recommended, and that for exceptional cases only, because the resultant scarring will of necessity be greater than that of the original trouble, and too often the new cicatrix undergoes hypertrophy; doubtless some of the cases are closely allied to, if not a variety of, keloid.

FIG. 192.



Keloid (original).

KELOID.—This is a connective-tissue neoplasm arising in a scar, and may develop single or multiple tumors (Fig. 192).

Symptoms.—Commencing usually as a small elevated nodule, as it slowly enlarges it tends to assume an elongated oval form with irregularly radiating, well-defined projections, presenting a rude resemblance to a crab; or, again, it may affect a linear form. The growth—generally devoid of hair—is a smooth, firm, elastic, pale-red, elevated, cicatrix-like mass, usually painless, but some-

times, especially on pressure, the reverse; more rarely itching is complained of. Its favorite site is over the sternum, but it is met with over the *mammæ*, on the neck, ears, arms, and elsewhere. In those rare instances where it becomes inflamed, keloid may present a temporary appearance of malignancy, but this condition usually subsides spontaneously. The course may be either rapid or slow, but, having reached a certain point, a keloid is apt to remain stationary for a time or for life, although it sometimes disappears. Although it is stated that keloid can arise spontaneously, it usually starts from some trauma of the skin, as the scars of burns, cuts, floggings, or the perforations in the lobes of the ears for ear-rings. The colored race is decidedly more liable to the development of keloid than the white. Microscopically, the growth consists of dense fibrous tissues involving the corium and extending especially along the adventitious tissue of the vessels.

Prognosis.—Although, as has been stated, keloid sometimes disappears, the outlook is not very favorable; temporary arrest in growth may continue for years, yet the growths may again enlarge.

Diagnosis.—This is easy, the only condition with which it can be confounded being a simple cicatrix, which differs in color, outline, elevation, and consistence; moreover, scars do not increase in size.

Treatment.—This is unsatisfactory. Removal by the knife or caustics should never be undertaken while the growth is enlarging; if any caustic is used, the best is *potassa fusa*. Repeated scarifications (see *Lupus*) or multiple electrolytic punctures may succeed. Anodyne liniments or morphine hypodermatically may be required to relieve pain.

LUPUS.

As *lupus vulgaris* is the variety of chief interest to the surgeon, *lupus erythematosus* will be merely incidentally described under the head of differential diagnosis. *Lupus vulgaris* is a chronic new-cell growth, due to the *bacillus tuberculosis*, which forms variously-sized reddish or brownish masses consisting of an aggregation of papules or tubercles, the usual termination being ulceration followed by cicatrization.

Symptoms.—The disease commonly begins in youth as small, yellowish or reddish-brown points beneath the skin, which increase and coalesce, forming irregular roundish or serpiginous, ill-defined patches; papules usually form and enlarge until they become tubercles; the lesions vary from the size of a pin-head to that of a pea, and are covered with ill-formed epidermis. They may be either firm or soft, and are painless. One of two changes follows: viz. retrogression by absorption of the lesions takes place, leaving a thin cicatricial tissue covered with desquamating epithelium; or ulcerative destruction of the infiltrated skin occurs, with subsequent cicatrization, producing much disfigurement. While the limbs and trunk may be attacked, the nose, cheeks, and ears are the favorite sites; it destroys the nasal and palpebral cartilages, and even the eye when attacking the face, sometimes also extending into the mouth. The extremities are frequently attacked, especially the fingers, the disease then often resulting in serious deformity. It is never congenital, is rarely hereditary, is uncommon among native Americans, and usually attacks only debilitated, underfed persons of the lower classes.

Diagnosis.—Syphilitic lesions most closely resemble those of *lupus*, and the distinction must depend chiefly on the history, in conjunction with the following facts: lupous ulcers are relatively superficial and less extensive; syphilitic ulcers are deep, excavated, and extensive; the numerous spots of ulceration in *lupus* tend to become confluent; syphilitic ulcers usually remain distinct, and,

moreover, have sharply-defined margins; the secretions of lupous ulcers are thin, brownish, scanty, and inodorous, while those of syphilitic ulcers are thick, often greenish, abundant, and offensive; lupous ulceration is slow, taking years to reach the same size that a syphilitic ulcer would attain in the same number of weeks; the lupous scar is yellowish, hard, and distorted; that of syphilis is smooth, thin, whitish, and small compared to the extent of the original ulceration; finally, a history of other syphilitic manifestations is often obtainable in syphilitic ulceration. (See p. 159.) Lupus erythematosus usually appears after puberty, beginning as an erythema; the orifices of the sebaceous glands are often gaping and distended with hardened sebum; ulceration never occurs, and after the disease disappears a cicatricial appearance of the skin is left. Epithelioma is more localized, is painful and circumscribed; induration exists; epithelial ulceration usually extends from one point, while that of lupus has a multiple origin; finally, epithelioma is rarely a disease of youth.

Prognosis.—If limited, the prognosis is fair, but when the disease is extensive it is very stubborn and results in marked scarring and deformity.

Treatment.—In the early stages cod-liver oil, combined with iodine and phosphorus, should be faithfully tried, with stimulating absorbent applications, such as equal parts of tincture of iodine and glycerin, mercurial plaster, tar ointment, or the ointment of red iodide of mercury. Linear scarifications, repeated as often as necessary, making numerous parallel cuts which must be crossed at various angles by others similarly disposed, is often very successful, leaving eventually a healthy scar; or the galvano-cautery may be employed under anesthesia. When milder measures fail, recourse must be had to caustics, of which chloride of zinc and pyrogallie acid are the best. Caustic potassa, in stick form, should be bored into the diseased parts, and be promptly neutralized by dilute acetic acid or vinegar. The papular and tubercular masses can sometimes be successfully treated by working a stick of nitrate of silver into them, while the patches should be repeatedly painted over with a saturated solution of the same: this is said not to leave scars. One dram of pyrogallie acid to the ounce of ointment, applied thickly on lint twice daily, often does well. Freezing the parts with rhigolene or ether and curetting with small, sharp curettes, supplemented by applications of pyrogallie acid, is an excellent measure; or still better the patient may be etherized and thorough erasion of the patches be done with the sharp spoon. Where the patches are of suitable size and in a favorable position, excision is proper. Koch's lymph, especially in the modified form (see p. 80), has seemed to be of more service in lupus than in any other form of tuberculosis.

PERFORATING ULCER OF THE FOOT.—This is often a misnomer, no true ulcer being present, but an opening communicating with a sinus, the orifice being perhaps surrounded with granulations, and the neighboring skin only slightly inflamed; sometimes, however, the skin is extensively ulcerated: the opening may be in the center of a corn. The usual position is over the metatarso-phalangeal joint of the great or the little toe, although other parts may be affected and several points at the same time; one or sometimes both feet may be attacked. The discharge is generally slight and sanious, and the opening is found by probing to be the orifice of a sinus leading down to diseased bone. There is marked insensibility of the diseased part, and a varying amount of anesthesia exists over an irregular area, extending sometimes to just below the knee; the toes are especially anesthetic. The local temperature is usually reduced; during the early stages abnormally free sweating occurs, and later, owing to organic changes in the tendons, distortion of the toes follows: the nails are yellow, cracked, and twisted laterally. Increased epithelial formation occurs

upon the sole and dorsum of the foot, while the hairs and the depth of color of the skin are increased. Dissections show the foot to be traversed by sinuses leading to carious bone, inflamed bursæ, and opened joints with eroded cartilages. These changes result from thickening of the endoneurium, with compression and destruction of the sensory nerve-fibers. Contusion of the foot by injuring a peripheral nerve may cause perforating ulcer, or the nerve lesion may possibly be central.

Prognosis.—This is doubtful, owing to the liability to recurrence from the persistence of the nerve lesions, even if healing should occur after rest.

Treatment.—In its early stages prolonged rest in bed, or even the use of an artificial limb attached to the bent knee, will often secure temporary healing, but, in most cases, as soon as the member is used again the sore recurs. Excision of the ulcer is useless, nothing short of a Syme or a Pirogoff amputation availing. These measures are usually successful, for, although the whole anesthetic area is not removed, experience shows that the skin of the heel is able to bear the pressure without ulceration; occasionally amputation below the knee is requisite, beyond which point the anesthesia probably never extends.

MALIGNANT DISEASES OF THE SKIN.

EPITHELIOMA may be either superficial or deep-seated, the former appearing as small yellowish-red papules or flattened aggregations of the same, situated in the upper layers of the skin, which eventually crack or become excoriated, giving vent to a scanty watery or viscid secretion drying into thin brownish crusts; the patch enlarges by additions to its periphery, and finally breaks down into a superficial, spreading, rounded or irregular ulcer, its border usually elevated into a "pearly ridge," although this may be level with the skin, with a sloping or sharply defined edge: the base is infiltrated, hard, bleeds readily, and secretes a scanty viscid fluid. Pain is rarely complained of, and involvement of the lymphatic glands seldom occurs. Unless the disease develops into the infiltrating variety, the ulcer when once formed remains almost unchanged in extent for a long time.

RODENT ULCER, a variety of epithelioma, in this superficial form is most frequently situated at the inner canthus or upon the side of the nose. It is a disease of late adult life. It commences as a thickening of the skin which continues to extend as a flattened nodule, and, becoming centrally abraded, degenerates into an ulcer, at first of a rounded form, later irregular in outline. The base and margins are indurated, the latter being somewhat abrupt or rounded, firm, and slightly elevated. The surface of the ulcer is smooth or slightly granular, glossy, dry and of a pinkish-red color. Progressing slowly and attended with but little pain, although cicatrization may occur at spots, the disease is never spontaneously arrested, everything in its course being destroyed, including the bones, until the orbits, nose, and mouth may form one crater-like opening; in advanced cases severe hemorrhage from ulceration of large vessels is not uncommon.

DEEP-SEATED EPITHELIOMA begins as a small reddish tubercle or warty growth involving the whole skin and subcutaneous tissue, with an indurated, infiltrated base; usually within a few months, from failing nutrition, ulceration begins at the older portions, producing an irregular ulcer with a foul, bleeding, indurated base. Pain is often severe, lymphatic involvement occurs sooner or later, and death results from exhaustion due to pain, discharge, and septic absorption. The most common sites are the lips, tongue, nose, eyelids, forehead, scalp, penis and scrotum, and labia. Chronic ulcers, old cicatrices which have become irritated, and psoriasis may all degenerate into epithelioma,

and chronic irritations, such as those caused by a jagged tooth, by pruritus ani, etc., may give rise to the disease.

Diagnosis.—This must depend upon the points already given, upon the rapid growth and early ulceration of a flattened tubercle or wart, induration of the base of the ulcer, age over forty years, and involvement of the lymphatics.

The **treatment** is free removal, including an area of healthy tissue. The knife, galvano-cautery, or caustics such as potassa fusa or pyrogallic acid, after freezing and curetting, may be employed.

CARCINOMA.—This occurs in three forms: 1. The **lenticular** or **scirrhus** form commences as slowly-growing, smooth, shiny, brownish-red, flat, disseminated papules or tubercles, which later become confluent; these are painful, ulcerate, involve the lymphatics, and recur after removal, finally destroying life. 2. The **tuberous** form occurs as firm, hard, flattened, raised, rounded, or oval nodular masses, varying in size from that of a pea to an inch or more in diameter, involving the skin and the underlying tissue. They are dull red, multiple, discrete, or confluent, and terminate by ulceration, lymphatic infection, and death. 3. **Melanotic carcinoma** commences as small, multiple, rounded or oval, soft or moderately firm papules, finally becoming confluent. They are brownish, purplish, or black, ulcerate, often forming gangrenous fungating ulcers, involve the lymphatics, and eventually cause death: this variety usually commences in a mole or pigmented wart on the hands or feet during early adult or middle life.

Cancerous ulcers differ from simple ulcers as follows: The malignant ulcer is excavated, with elevated, everted, knobby, sinuous margins. The base is nodular, infiltrated, and therefore *fixed*, often readily bleeds when touched, is granular, livid, or covered with yellowish or grayish sloughs, and exudes a profuse offensive ichorous or sanious discharge, which usually excoriates the surrounding skin. The ulcer tends to spread continuously in extent and depth, involving all the tissues, even bone, in its path. The breaking down is preceded by a nodular irregular infiltration of the tissues and skin, the latter often presenting a livid-red or violaceous, glazed appearance. Here and there nodular or tubercular cancerous infiltrations are often seen, situated some distance from the ulcer, with comparatively or—to the eye—absolutely normal skin intervening. Again, much of the surrounding skin may be more evenly infiltrated and fixed to the subjacent parts, presenting the well known “hog-skin” appearance.

Treatment.—The same as for epithelioma.

SARCOMA occurs as small single or multiple, variously-sized discrete tubercles or tumors, which may or may not be pigmented. Smooth, firm, elastic, slightly tender on pressure, the non-pigmented tumors are reddish, purplish, or brownish red. The multiple pigmented sarcoma is described as invariably commencing on the plantar and dorsal surfaces of the feet. Sarcoma occurs toward middle life and pursues a malignant course. Ulceration of sarcoma of the skin does not usually produce much destruction of tissue. When involving the deeper parts or organs, as the breast, and ulceration occurs late, secondarily attacking the skin, and extends rapidly, the ulcer presents a foul, fungous appearance, the margins are not indurated to any extent, and the discharges are abundant, often bloody, and sometimes offensive. Free hemorrhage is not uncommon.

Treatment.—Fowler's solution diluted with two parts of distilled water, given hypodermatically twice daily, commencing with two drops and increasing to its physiological limit, seems to be the only remedy which has proved successful. Early amputation is to be done where possible.

BOOK III.

REGIONAL SURGERY.

CHAPTER I.

DISEASES AND INJURIES OF THE HEAD.

I.—GENERAL CONSIDERATIONS.

INJURIES of the head are peculiarly important from the fact that they may not be limited to the external soft parts and the bones, but may involve the brain, the great nervous center on the integrity of which life itself depends. The brain is well protected against ordinary injuries by moderate violence. Not only is the head covered with the dense, fibrous scalp, but the brain is further encased and defended by the hard, bony skull, which is practically a closed box, the thickness of which varies in different persons and in different regions. This bony case is arched on its upper surface, so that blows which would otherwise fracture and penetrate the skull glance from this curved surface and do but little harm. Moreover, the bones are distinctly resilient and elastic, yielding before a blow, but springing back to their former position without fracture unless the violence be too great. Its elasticity of course diminishes from youth to age. It is made up also of a number of bones united edgewise at the sutures, which to some extent diminish and dissipate the violence inflicted upon the skull, although a fracture often crosses the sutures. Moreover, a blow of sufficient violence may produce a fracture either at the point where it is inflicted, or, occasionally, though rarely, at a point opposite that at which the blow was received. This last form of fracture is called fracture by *contrecoup*, or counter-stroke. It should be observed that injury by counter-stroke is much more frequent in the brain than in the skull. There are a number of instances on record where a blow received on one side of the head has produced laceration of the brain, and even of the middle meningeal artery, on the opposite side. It will be seen, therefore, that in such cases if an operation is done, the question on which side of the skull it shall be done is to be determined by localizing brain symptoms rather than by the external evidences of injury.

Inside of this bony case lies the brain surrounded by its membranes, and more or less steadied and protected by a small amount of fluid normally existing in the skull, both on the outside of the convolutions and in the ventricles themselves. Not uncommonly there is a distinct area of oedema in the pia which undoubtedly acts as a buffer in fending off a blow, but in spite of this the brain must be looked upon as a soft mass of tissue more or less easily lacerated by commotion or shaking from blows and falls, even without any fracture of the bones.

Both the brain and its membranes are subject to inflammation, which is followed by irritation and later by exudation, swelling, and pressure, and the exudate cannot escape through the thick skull and scalp except a means of

exit be offered by the surgeon. Hence the frequent need for trephining. The pressure of this exudate may be relieved to some extent by the escape of some of the intracranial blood and of some of the cerebro-spinal fluid into the spinal canal; but if the pressure increases, the functions of the brain must be interfered with and become altered or even abolished, while the irritation may cause an exaltation of function. This alteration or abolition may apply to the intellectual, the sensory, or the motor functions of the brain, so that there may be mania or coma, hyperesthesia or anesthesia, and spasm or paresis or paralysis.

Moreover, the interference with function may be general, or if the pressure be local the alteration or abolition of function will be local, at least at the beginning, so that there will be paresis or paralysis of an arm or a leg, or of half the face; alteration or abolition of speech, either sensory or motor; hemianopsia if one cuneus be involved; and, if there be inflammation of or pressure on the optic nerves or tracts, optic neuritis will develop. Sometimes the alteration will be obscure, and functional rather than organic, so far as we can discover, and will produce headache, epilepsy, or insanity, without any perceptible change in the brain substance. When pressure is produced by a blood-clot, caused by a blow with or without fracture, and followed not uncommonly by a cyst, epilepsy is a not infrequent sequel. It seems also to be probable that the scar resulting from laceration of the brain tissue, even in simple fracture or contusion, may be followed by epilepsy, and that this may be relieved by the excision of the ragged scar and the substitution of a clean cut in the brain tissue. So far as we know, such an incised wound of brain tissue made antiseptically heals without being followed by the irritation which occurs after laceration of the brain.

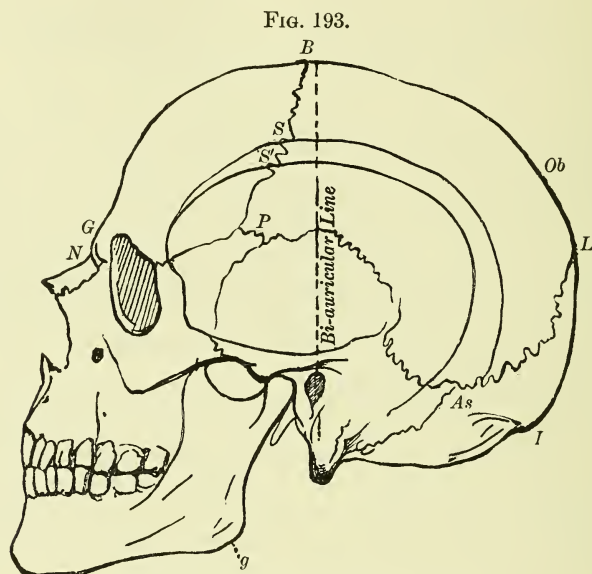
While the general anatomical facts here stated have been of course long known, yet the localization of function in various parts of the brain has been proved and accepted only in the last twenty years, while cerebral surgery founded upon it practically began only in 1884. Broca in France, Goltz, Fritsch, and Hitzig in Germany, and Ferrier and Horsley in England, have done the principal work in solving the neurological problem, while Macewen and Horsley in England have created a new department in surgery. Until ten years ago the skull was regarded as a region so dangerous that Dante's motto might have been an appropriate warning: "Abandon hope, all ye who enter here;" and though there were occasional accounts of extraordinary and unexpected recoveries from accident, yet purposeful interference with the brain and its membranes was never to be thought of except where compound fracture with serious brain symptoms made it absolutely needful, and then it was undertaken with reluctance and fear. This was due, first, to our ignorance of the localizing value of the different parts of the brain, which differ from one another in function as much as the different viscera of the abdomen *inter se*; and secondly, to our ignorance of the fact, now amply proved, that if we employ the rigid antiseptic details practised by Macewen, and fully formulated by Horsley so late as 1886 and 1887, we can invade the skull-cavity with far less danger than was formerly thought possible. Inflammation and supuration should rarely follow, provided antiseptic precautions are strictly followed. These precautions are given in detail under the head of Technique. They must be observed to the letter in every operation, no matter how slight, which can possibly involve the brain-cavity.

This revelation of the function of the various parts of the brain, and the similar revelation of the operative possibilities, have exercised a marked influence upon recent surgical practice. The aim of the present text-book will be

to place the surgeon abreast of the most recent experience; but, where treatment is of doubtful or as yet unproved value, a proper conservatism will be advocated; for it must still be recognized that any operation involving the brain is a very serious one and may be attended with danger to life.

II.—TOPOGRAPHY OF THE BRAIN IN ITS SURGICAL RELATIONS.

The situation of the chief fissures and convolutions of the brain, and therefore of the various ascertained cortical centers, has of late assumed the greatest importance, and they have frequently been mapped out on the exterior of the skull with almost absolute accuracy, without any other guide than the rules given below. Fig. 193 shows the points named by Broca on the skull,



Skull showing the Points named by Broca.

As, asterion (junction of the occipital, parietal, and temporal bones); *B*, basion, middle of anterior wall of foramen magnum; *B*, bregma (junction of the sagittal and coronal sutures); *G*, ophryon (on a level with the superior border of the eyebrows, and corresponding nearly to the glabella, the smooth swelling between the eyebrows); *g*, gonion (angle of the lower jaw); *I*, inion (external occipital protuberance); *L*, lambda (junction of sagittal and lambdoidal sutures); *N*, nasion (junction of the nasal and frontal); *Ob*, obelion (the sagittal suture between the parietal foramina); *P*, pterion (point of junction of great wing of sphenoid and the frontal, parietal, and squamous bones. This may be H-shaped or K-shaped, or "retourné," in which the frontal and temporal just touch); *S*, stephanion (or, better, the superior stephanion, intersection of ridge for temporal fascia and coronal suture); *S'*, inferior stephanion (intersection of ridge for temporal muscle and coronal suture).

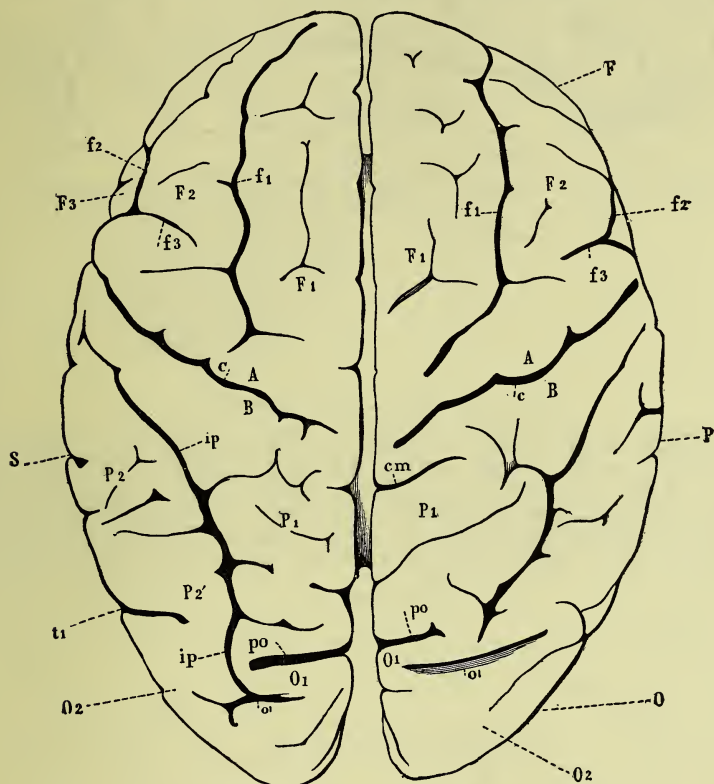
and Figs. 194, 195, and 196 show the chief fissures and convolutions of the brain.

The fissure of Bichat between the cerebrum and the cerebellum corresponds to a line drawn from the inion to each external auditory meatus. The median fissure between the two hemispheres is slightly to the right of the median line, the left hemisphere in right-handed persons being slightly larger than the right, and *vice versa* in left-handed persons. The two lines just given also correspond respectively to the lateral and superior longitudinal sinuses.

The other three leading fissures which it is important to be able to locate on the exterior of the skull are, 1, the fissure of Rolando; 2, the fissure of Sylvius; and 3, the intraparietal fissure; especially the first two.

1. **The Fissure of Rolando** (Figs. 194, *c*, and 195, *c*), as Thane has shown, starts from a point which lies back of the glabella 55.7 per cent. of the distance from the glabella to the inion, and runs downward and forward at an angle of 67° , its average length being $3\frac{3}{8}$ inches. The lower third of the fissure changes to a somewhat more vertical direction. Practically, the fissure of Rolando commences half an inch behind the mid-point between the glabella and the inion. Mr. Horsley states that in a head with a cranial index of 75^1 the fissure

FIG. 194.



View of the Brain from Above (Ecker).

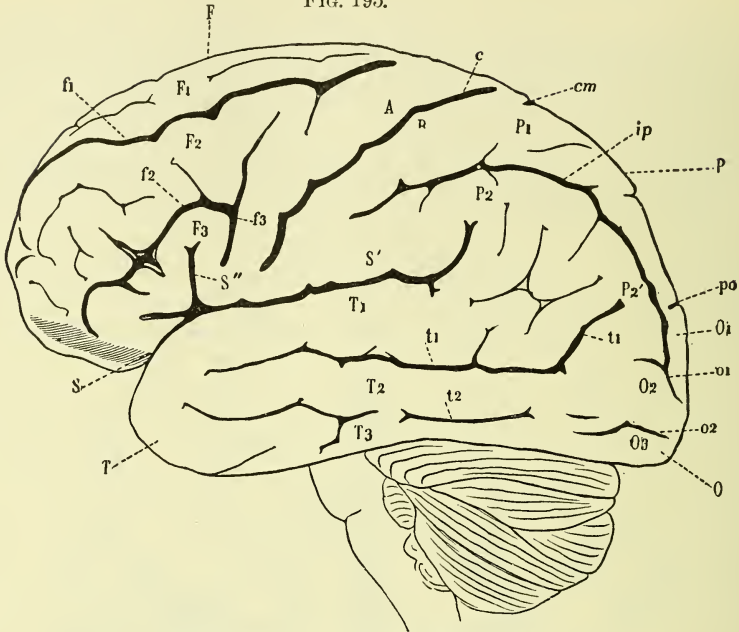
A, anterior central or ascending frontal convolution; *B*, posterior central or ascending parietal convolution; *c*, central fissure or fissure of Rolando; *cm*, callosal-marginal sulcus; *F*, frontal lobe; *F*₁, upper, *F*₂, middle, *F*₃, lower frontal convolution; *f*₁, superior frontal sulcus; *f*₂, inferior frontal sulcus; *f*₃, vertical fissure (sulcus præcentralis); *ip*, intraparietal sulcus; *O*, occipital lobe; *o'*, sulcus occipitalis transversus; *O*₁, first occipital convolution; *O*₂, second occipital convolution; *P*, parietal lobe; *po*, parieto-occipital fissure; *P*₁, upper or postero-parietal lobule; *P*₂, lower parietal lobule, constituted by *P*₂, gyrus supramarginalis, and *P*₂', gyrus angularis; *S*, end of the horizontal branch of the fissura Sylvi; *t*₁, upper temporal fissure.

runs at an angle of 69° , the angle increasing or diminishing one degree for every two degrees of increase or decrease in the cranial index. In all ordinary cases, however, the fixed angle of 67° will be found sufficient.

Chiene's Method.—Mr. John Chiene of Edinburgh has proposed a method of fixing the position and length of the Rolandic fissure which is at once simple, ingenious, and always available. He folds a square piece of paper once (Fig. 197, ABCD), on the diagonal line AC. The angle BAC is then evidently 45° . The angle DAC (45°) is then halved (22.5°) by folding the

¹ The cranial index is found by dividing the transverse diameter of the head by the antero-posterior diameter.

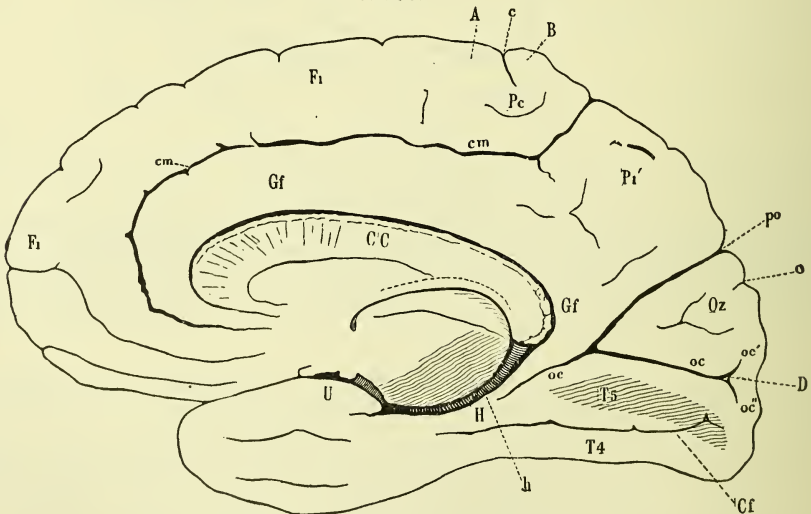
FIG. 195.



Outer Surface of the Left Hemisphere (Ecker).

A, anterior central or ascending frontal convolution; B, posterior central or ascending parietal convolution; c, sulcus centralis or fissure of Rolando; cm, termination of the callosal-marginal fissure; F, frontal lobe; F₁, superior, F₂, middle, and F₃, inferior frontal convolutions; f₁, superior, and f₂, inferior frontal sulci; f₃, sulcus præcentralis; ip, sulcus intra-parietalis; O, occipital lobe; O₁, first, O₂, second, O₃, third occipital convolutions; o, sulcus occipitalis transversus; o₂, sulcus occipitalis longitudinalis inferior; P, parietal lobe; po, parieto-occipital fissure; P₁, superior parietal or postero-parietal lobule; P₂, inferior parietal lobule, viz.: P₂, gyrus supramarginalis; P₂, gyrus angularis; S, fissure of Sylvius, S', horizontal, S'', ascending ramus of the same; T, temporo-sphenoidal lobe; T₁, first, T₂, second, T₃, third temporo-sphenoidal convolutions; t₁, first, t₂, second temporo-sphenoidal fissures.

FIG. 196.



Inner Surface of Right Hemisphere (Ecker).

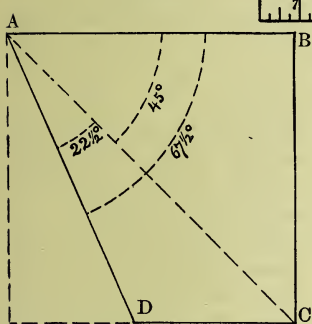
A, ascending frontal; B, ascending parietal convolution; c, terminal portion of the sulcus centralis, or fissure of Rolando; CC, corpus callosum, longitudinally divided; Cf, collateral or occipito-temporal fissure (Ecker); cm, sulcus callosal-marginalis; D, gyrus descendens; F₁, median aspect of the first frontal convolution; Gf, gyrus fornicatus; H, gyrus hippocampi; h, sulcus hippocampi, or dentate fissure; o, sulcus occipitalis transversus; oc, calcarine fissure; oc', superior, oc'', inferior ramus of the same; O₂, cuneus; Po, paracentral lobule; po, parieto-occipital fissure; P₁, precuneus; T₄, gyrus occipito-temporalis lateralis (lobulus fusiformis); T₅, gyrus occipito-temporalis medialis (lobulus lingualis); U, uncinate gyrus.

paper again on the line AE. The sum of the angles BAC and CAE is evidently 67.5° , which is near enough for all practical purposes to the angle of the fissure of Rolando. The side AB is then applied to the middle line of the head, the point A being placed half an inch behind the mid-point between the glabella and the inion, when the line AE will correspond to the fissure of Rolando.

The length of the fissure being $3\frac{3}{8}$ inches, Mr. Chiene suggests that every man who has seen his mother measure her tape on her right forefinger should know what point on his own right forefinger corresponds to $3\frac{3}{8}$ inches in length. This will give the length of the fissure of Rolando on the line AE.

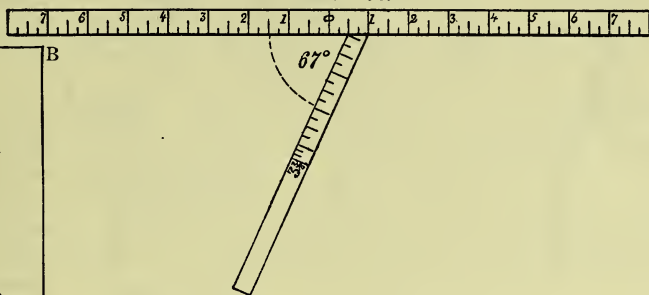
Mr. Horsley has devised an instrument made of metal or of two strips of parchment paper, as shown in Fig. 198, the antero-posterior arm being 14 inches

FIG. 197.



Chiene's Method of Fixing Position of Rolandic Fissure (original).

FIG. 198.



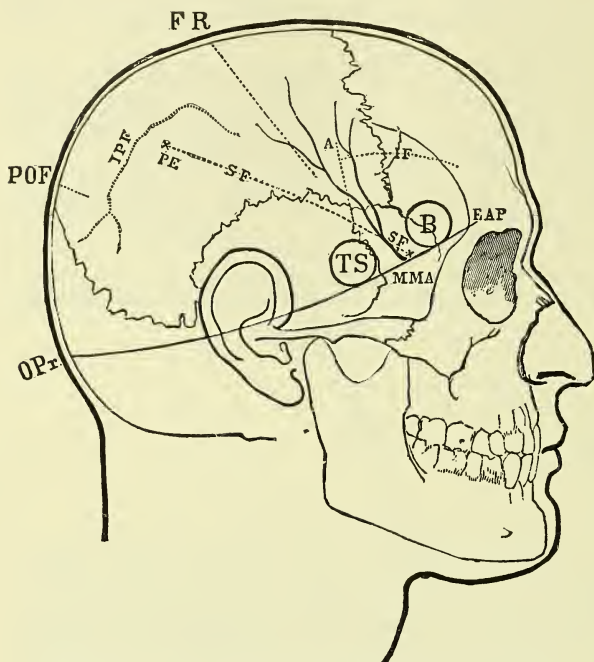
Horsley's Cyrtometer (as modified by Dr. Morris J. Lewis).

long, and the lateral arm being placed at an angle of 67° . The scale of this instrument starts from the zero point (half an inch in front of the lateral arm), and runs both forward and backward. To determine the fissure of Rolando, place the antero-posterior arm in the middle line in such a position that the glabella and the inion will each mark the same distance from the zero point on the scale; for instance, each six or six and a half or seven inches. The lateral arm will then correspond to the fissure of Rolando, except in the lower third, where, as already stated, the fissure becomes slightly more vertical. To admit of its use on both sides of the skull the lateral arm should be made reversible right and left, or the whole instrument may be reversed from side to side if it is graduated on both sides. Or one may use Wilson's cyrtometer, consisting of two strips of flexible metal at right angles to each other, forming a letter T, the horizontal strip secured to the head by a tape, with the lower border corresponding to the glabella and the antero-posterior arm in the middle line. On the antero-posterior arm there are two scales numbered from A to Q and from a to q. These are so placed that in any position the distance from the glabella to a, b, c is 55.7 per cent. of the distance from the glabella to A, B, C. If, then, A corresponds to the inion, the lateral arm is placed at a; if the inion corresponds to B, the lateral arm is placed at b, etc., and when placed in its proper position will indicate the position of the fissure of Rolando. In children below nine years of age the fissure is much more oblique (even down to 52°), and lies farther forward on account of the slighter development of their frontal lobes.

The importance of fixing the fissure of Rolando will be especially appreciated in observing the motor centers which cluster around this by far the most important of the cerebral fissures.

2. The Fissure of Sylvius (Fig. 195, S, S', S'', and Fig. 199, SF and A).—To fix this fissure, draw a line from EAP (Fig. 199), the external angular

FIG. 199.



Head, Skull, and Cerebral Fissures (adapted from Marshall by Hare).

B corresponds to Broca's convolution; EAP, external angular process; FR, fissure of Rolando; IF, inferior frontal sulcus; LPF, intraparietal sulcus; MMA, middle meningeal artery; OPr, occipital protuberance; PE, parietal eminence; POF, parieto-occipital fissure; SF, Sylvian fissure; A, its ascending limb; TS, tip of temporo-sphenoidal lobe. The pterion (to the left of B) is the region where three sutures meet, viz., those bounding the great wing of the sphenoid where it joins the frontal, parietal, and temporal bones.

process, to OPr, by the shortest route between these points. This usually passes at about half an inch above the meatus. The fissure of Sylvius begins one and one-eighth inches posterior to the external angular process on this line, and from this point the main line of the posterior branch of the fissure of Sylvius (Fig. 199, SF) runs in a direct line toward the parietal eminence, PE. The ascending or anterior limb of the fissure corresponds closely to the squamoso-sphenoidal suture in its entire length, and is continued upward in the same line for half an inch or more (Fig. 199, A). The middle meningeal artery is shown in the same figure in its relation to the Sylvian and Rolandic fissures.

The pre-central sulcus, or, as it is often called, the vertical sulcus (Fig. 195, f^3) is of

great importance, as it limits the pre-Rolandic convolution anteriorly. It is sometimes joined by the inferior frontal sulcus (Fig. 195, f^2). It runs parallel to and just behind the coronal suture, at the width of one convolution in front of the fissure of Rolando. Its upper end does not extend as far as the superior frontal sulcus. The pre-Rolandic or ascending frontal convolution bends around the lower end of the pre-central sulcus, and forms a crescentic convolution which lies in the hollow of the two limbs of the fissure of Sylvius and is continuous anteriorly with the third frontal convolution. It is called the *operculum*, and in it, especially in its anterior portion (the base of the third frontal convolution), is Broca's center for speech.

There are two frontal sulci, the superior and inferior, which divide the frontal lobe into three convolutions: the superior, middle, and inferior, or first, second, and third, frontal convolutions. The *superior frontal sulcus* (Figs. 194 and 195, f^1) starts from the pre-Rolandic convolution about midway between the fissure of Rolando and the line of the pre-central sulcus. The *inferior frontal sulcus* (Figs. 194 and 195, f^2) starts from the vertical sulcus and runs forward parallel with the superior frontal sulcus. It lies about on a level with the superior temporal ridge or superior stephanion (Fig. 193, S).

3. The **Intraparietal Fissure** (Figs. 194 and 195, *ip*) lies posterior to the fissure of Rolando, and is the posterior boundary of the motor region. It begins opposite the junction of the middle and inferior thirds of the fissure of Rolando. Passing upward, it lies midway between the fissure of Rolando and the parietal boss. It then diverges from the fissure of Rolando posteriorly, and thus widens the upper end of the post-Rolandic convolution to such an extent that the upper end of this convolution is known as the *superior parietal lobule* (Figs. 194, 195, and 196, *P*¹). In the middle of its course the intraparietal fissure runs about parallel to the great longitudinal fissure and midway between it and the parietal boss. Farther back it passes by the parieto-occipital fissure and downward and backward into the occipital lobe. Below its curve, at the ends of the Sylvian and first temporal fissures respectively (*S*¹ and *t*¹, Fig. 195), are the **supramarginal** (*P*₂) and **angular** (*P*₂') gyri. Once these fissures are determined from the outside of the skull and the brain exposed, the latter can be faradized, and the exact localization of the motor cortical centers can be determined by the movements produced by faradization. This has been done in a number of cases with unexpected accuracy.

For a more minute localization of the other fissures and convolutions of the brain the reader is referred to the last American edition of Gray's *Anatomy*, p. 681, and to the article on "The Surgery of the Brain," Buck's *Reference Handbook of the Medical Sciences*, vol. viii. p. 201.

Figs. 200 and 201 show the position of the chief motor areas in the brain of the monkey, as determined by Horsley and Schafer, which correspond closely, as has frequently

FIG. 200.

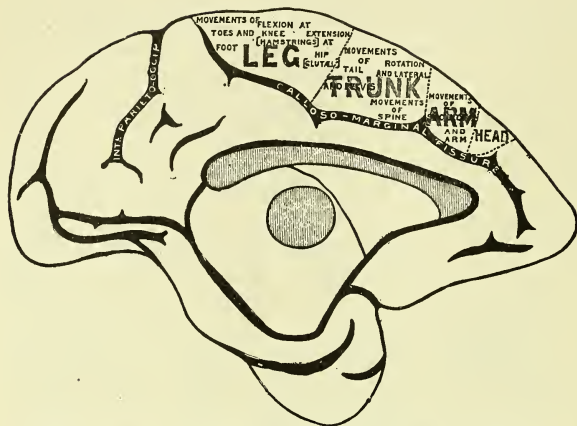


Motor Areas on the Outer Surface of the Brain (Horsley and Schafer).

been shown, to the same cortical centers in man. Roughly speaking, the upper third of the convolutions in front of and behind the fissure of Rolando corresponds to the center for the movements of the **leg**; the middle third corresponds to those for the **arm** (beginning at the upper end with the **shoulder center**, the middle part the **elbow center**, and the lower the **hand center**). In the lower third lie the **face center** and the center for the **mouth and larynx**. The centers for the face, leg, and trunk, it will be noticed in Fig. 201, are largely situated on the median surface of the hemispheres as well as on their external surface. Broca's center for **speech** lies just in front of the end of the fissure of Rolando, and in the angle formed by the main trunk and the anterior limb of the fissure of Sylvius.

The center for **vision** is situated chiefly in the **cuneus** (Fig. 196, *Oz*), a lesion of which produces blindness of the corresponding (right or left) half of both retinæ. The **supramarginal** and **angular gyri** are also probably concerned to some extent in **vision**. These same convolutions (supramarginal and angular) are the seat of certain **mental processes**, the abolition of

FIG. 201.



Motor Areas on the Median Surface of the Brain (Horsley and Schafer.)

which produces sensory aphasia, alexia, agraphia, apraxia, etc.; for the details of which see page 534. The center for **hearing** is probably situated in the middle and posterior parts of the **first temporo-sphenoidal convolution** (Fig. 195, T¹). The center for **smell** is probably situated in the **uncus**, near the lower part of the **hippocampus major** (Fig. 196, U).

III.—TECHNIQUE OF CEREBRAL OPERATIONS.

We owe this chiefly to Mr. Horsley's brilliant papers. It is always of the utmost importance that the head should be shaved. This will often reveal scars, etc. hitherto unsuspected, and no definite diagnosis should ever be reached or an operation determined on without this procedure. The **fissures**, so far as is necessary, may be marked out on the shaven scalp by means of an aniline pencil, which is itself antiseptic. Of course, after being shaved, the patient should be protected against catching cold by a silk handkerchief or cap around the head. The day before the operation the head should be shaved anew if need be, scrubbed with soap and water, next cleaned with ether, and then covered with a sublimate dressing, the three or four inner layers of which may be wet with a sublimate solution 1:2000, as a 1:1000 solution might vesiccate. This dressing should be retained in place until the operation, when the disinfection should be repeated. There is no need for the spray. Of course all the ordinary operative precautions described elsewhere, as to the thorough cleansing of the finger-nails, hands, and arms of the operator and his assistants, should be carried out with scrupulous care.

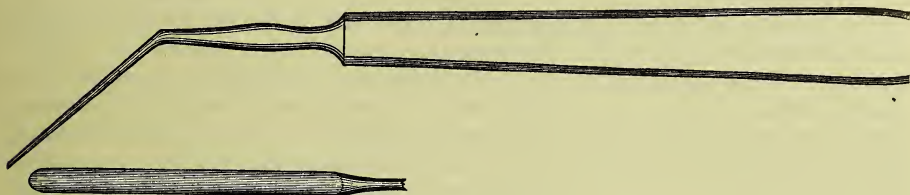
Ether or chloroform may be used, and it is better to operate with the patient in the **semi-recumbent position** rather than lying flat, in order to diminish the amount of hemorrhage. It is important to mark three points on the **bone**: viz. the place at which the center pin of the trephine is to be applied, and the upper and lower ends of the fissure of Rolando at points just outside the flap, in order that the fissure may be recognized after the flap has been raised. This is best done by using the center pin taken out of another trephine, by means of which a little triangular point can be marked on the bone, using the rongeur forceps, for example, as a hammer, or a very small gouge will nick the bone sufficiently to enable it to be recognized.

The **flap** to be raised should be of a horseshoe shape, with a diameter of about three inches. As a rule, the base of the flap should be below, on account of the more favorable blood-supply. The flap of periosteum should be raised with the scalp. The hemorrhage is best controlled by seizing the edge of the flap at the bleeding points with hemostatic forceps.

The **trephine opening**, with rare exceptions, should be large, not less than $1\frac{1}{2}$ inches. Once the trephine opening is made, it can be enlarged by the rongeur forceps (Fig. 203) to any extent desired. Before enlarging it the dura

should be separated from the bone by Horsley's dural separator (Fig. 202), by means of which also the inner surface of the skull can be explored, and any irregularities detected, two inches or more from the trephine opening.

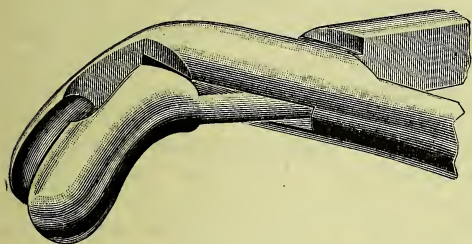
FIG. 202.



Horsley's Dural Separator.

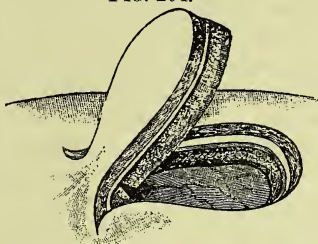
Osteoplastic Resection.—In 1889, Wagner, following an earlier suggestion of Wolff, proposed to make a temporary osteoplastic resection by chiselling loose the piece of bone to be removed, except at one portion where it was fractured and turned back on the scalp as a hinge. The scalp is incised down to the bone, the flap not being loosened from it. By mallet and chisel the bone is then nearly cut through at every point excepting its base, the separation being completed by an osteotome. It is then lifted by means of elevators, the base being fractured, a window, so to

FIG. 203.



Hopkins' Rongeur Forceps.

FIG. 204.



Osteoplastic Resection of Skull by the Wagner-Wolff Method (Esmarch and Kowalzig).

speak, being opened by turning back the flap (Fig. 204). By this means access can be had to a very large area of the brain-cortex; even three, four, or five inches have been thus exposed. When the operation is terminated the opening is closed by replacing the flap, which is sutured in place as usual. In chiselling such a piece loose it is best to chisel it obliquely, so that the opening in the inner table will be a little smaller than that in the outer, the inner table thus forming a shelf on which the flap rests. The base of the flap, which serves as a hinge, should always be in that part of the flap having the largest blood-supply.

The surgical engine with a special drill and an electrical motor with a saw have been also used in place of the chisel.

"Trephining" in the remainder of this chapter will be used in the sense of opening the skull to obtain access to its interior, irrespective of whether the opening is made by the trephine, the chisel, or any other means.

As a rule, the *dura* should be opened. The additional danger is very slight, and the additional information may be very great. With rare exceptions, if we trephine at all the brain itself should be examined by sight and touch. The opening in the *dura* is best made parallel with the edge of the bone and a quarter of an inch away from its margin. Care should be taken

not to wound the large and troublesome veins of the brain immediately beneath the dura. This can best be avoided by lifting the dura with rat-toothed forceps while making the first incision by a knife, and then by using a blunt-pointed pair of scissors.

If **hemorrhage** occurs from any branch of the middle meningeal, it may be arrested by passing a ligature through the dura under the vessel by means of a fine semicircular needle, the finest Hagedorn being the best. For checking hemorrhage in the brain the chief reliance must be placed on catgut (non-chromicized). Some of the larger arteries can be tied directly, but in many cases it is better with the fine semicircular Hagedorn needle to pass a ligature through the brain substance and around the vessel, and tie it with great gentleness, care being taken to see that the traction on the two ends of the ligature is exactly even, in order not to tear the vessel. The knot must not be tied too tightly, or it will cut through the fragile vessel. Pressure continued for a few minutes by gauze or sponge and hot water at 105° to 115° will often serve a good purpose. Sometimes, especially in hemorrhage from the sinuses, the hemostatic forceps may be left for from thirty-six to forty-eight hours. Usually, however, pressure upon the sinuses or plugging them is the best means of controlling such hemorrhage. A lateral ligature may be used if the wound is small, or the entire sinus may be ligated if need be.

After opening the dura the first point to be observed is whether the **brain bulges** into the trephine opening, for if it does there is a pathological increase in the intracranial pressure, due to tumor, abscess, internal hydrocephalus, etc. Next observe the color. *Lividity* or a *yellowish tinge* will indicate a probable tumor beneath the cortex. An old laceration will usually show a dirty yellowish-brown. *Edema* of the membranes is not uncommon, even to such an extent as in great measure to obscure the sulci and convolutions. The serum will escape on nicking the membranes, and the sulci and convolutions may then be recognized. *Absence of pulsation* in the brain usually indicates a large tumor, abscess, or cyst. The density of the brain can best be determined by touch.

If the *brain tissue* be *abnormal*, the whole abnormal portion ought to be removed. In doing so we can cut much more freely antero-posteriorly than vertically without doing damage, as in the vertical direction other centers than the one we seek are more quickly encroached upon than by excision antero-posteriorly. (Compare Fig. 200.) When the brain is exposed, if we wish to *recognize any motor center by faradization*, no antiseptics should be used, as they all dull the reaction of the cortex to electricity, but only sponges or sterilized gauze wrung out of hot water. For faradization of the brain the ordinary faradaic battery suffices. The current should not be too strong, lest it do harm to the cortex. A current sufficient to stimulate the thenar muscles is that usually employed. A double brain electrode (Fig. 205) may be used

FIG. 205.



Double Brain-electrode (Keen).

with advantage. The points should be sterilized and the handle wrapped in antiseptic gauze. By applying the electrodes to various parts of the cortex the motor centers can be readily determined in most cases, even without opening the dura. Notes should be taken of the phenomena following each

application, and the situation of the points stimulated should be determined by exact measurements. A stenographer should be present to take the dictation of the observed phenomena rapidly and exactly. As a rule, it is *better not to drain* after cerebral operations, but occasionally, especially in cysts, drainage is a matter of importance. In abscesses, gunshot wounds, hemorrhage, etc. it is of course a necessity. Rubber tubing is the best means.

Not uncommonly the *bone* can be *replaced*. Even a $1\frac{1}{2}$ -inch button of bone will retain its vitality and re-establish its connection with the skull if properly cared for. In all cases, therefore, where there is a possibility of the replacement of the bone, the moment it is removed it should be placed in a bowl containing a 1 : 2000 sublimate solution, and the bowl be placed in a basin of hot water the temperature of which is kept at 105° to 100° F. This should be the sole care of one assistant. Instead of replacing it in one large piece, it may be bitten into small pieces by bone forceps. The pieces bitten away by the rongeur forceps may be similarly utilized. Sometimes Senn's decalcified ox-bone can be better used than the bone which has been removed. Of course if the bone be diseased or very compact, or it be desired to change the intracranial pressure, as in cases of headache, insanity, etc., the bone should not be replaced. In this case a small disk of tin can be advantageously secured to the inside of a skull-cap to protect the brain. To prevent adhesion of the brain disinfected gold-foil has been inserted. Fraenkel has recently filled the opening by a disinfected celluloid plate. König has proposed to fill the gap of an old fracture by chiselling a neighboring piece of the outer table away with a flap of scalp, sliding it into the opening, and covering the wound thus made by transplanting skin by Thiersch's method. If the dura has been removed, and it is still desired to replace the bone in one large piece, this may be perforated and secured to the under surface of the flap by catgut, then preferably chromicized.

After the operation on the brain is completed the dura should be sutured by interrupted or continuous catgut sutures as is desired. The scalp should now be replaced and secured by the ordinary interrupted sutures, and an abundant sublimate dressing, of which the inner layers may be again wet with a solution of the strength of 1 : 2000, should be applied. This should be covered with rubber dam, and be retained in place by a bandage and, especially in children or in restless adults, by a night-cap. As soon as the dressing is moistened to its margin by serous or bloody discharge the wound should be redressed. If a drainage-tube has been used, it should be removed at the end of from twenty-four to forty-eight hours, except in cases of abscess, etc., when it should remain for some days. In case no drainage has been provided, if too much blood and serum or cerebro-spinal fluid accumulates under the flap, as shown by its marked bulging and possibly by paralysis, the wound-fluids can be evacuated by inserting a probe or a pair of forceps between two stitches. As a rule, by the fifth or sixth day about half the stitches may be removed, and all of them usually by the seventh or eighth day. Absolute quietude, both of mind and of body, should be insisted upon, especially for the first week. No letters, visitors, or other causes of excitement should be allowed for some time. Though sometimes less severe restrictions may be required, yet this course should be enforced for two weeks, and in some cases even for months, after the operation.

Operation in Two Stages.—The severe shock in serious operations on the brain has led Horsley and other surgeons to modify the procedure by dividing it into two stages. The first stage consists in merely effecting an opening into the skull. This is then closed by a few temporary sutures.

After an interval of from three to six days the wound is reopened and the operation completed. This method is especially applicable to operations for brain-tumors and the removal of the Gasserian ganglion.

Secondary operations are not uncommonly required when the brain, its membranes, and the bone will all be adherent, and must be dissected free from one another with great care. Some of the brain tissue will of necessity be torn away, and more or less pronounced paresis of the centers corresponding to the interference may be produced. After removal of a motor center there is of course entire paralysis of the part supplied by this center; and the pressure caused by the blood-clot which accumulates and the later cell-proliferation is apt to cause widespread paralysis, amounting even to a hemiplegia. After some weeks this invariably disappears to a greater or lesser extent, leaving, however, the affected muscles, it may be, somewhat parietic.

If any portion of the **dura has been removed**, and especially if this is followed by removal of the brain substance, there is a marked tendency to proliferation of the cerebral tissue, with danger of a fungus cerebri forming. This may be prevented by taking a bit of the pericranium from the under surface of the scalp, turning the osteogenetic surface upward, and attaching it to the dura by interrupted sutures. The pericranium will very quickly contract adhesions to the dura, and the gap will be closed (Keen).

The **limits of operative procedure** are constantly being enlarged. Once the skull is trephined, we can explore the inner surface of the skull over a wide area by the dural separator or probe. If the dura has been opened, the finger can be gently inserted between the brain and the dura and the surface of the brain explored for at least an inch all around the opening in the dura. The brain can be readily depressed by the finger or the knife-handle used with gentleness, and the eye can see for an inch beyond the dural opening. If the opening be toward the base of the brain, the brain may be lifted either with or without the dura and the base of the skull explored for a considerable distance. The cerebellum can be lifted and the finger and the eye can reach to the foramen magnum. The sinuses can be safely uncovered and separated from the skull, and the frontal lobe lifted far enough to discover the anterior clinoid process, while laterally the surfaces of the petrous bone can be explored. The brain can be punctured almost with impunity, especially if a blunt instrument like a grooved director be used, so as not to wound the large vessels, and the ventricles can be tapped.

IV.—DISEASES INVOLVING THE SCALP.

I. Inflammation of the Scalp.—This is a frequent sequence of wounds, and will be referred to later. It is often caused by the poison ivy or poison oak and by erysipelas, and is described under these heads.

II. Tumors of the Scalp.—1. The most frequent of all are the *Sebaceous Tumors*, or *Wens*. The pathology of these tumors will be found in the chapter on Tumors. Their diagnosis is easy. They are frequently multiple, are of slow growth, vary in size from that of a pea to that of a small egg, are painless, and have an elastic, cystic feel. Occasionally, especially near the angle of the eye, they are dermoid in character, having a number of hairs intermingled with the sebaceous contents. Sometimes they ulcerate.

The **treatment** is extirpation. In removing them it is not necessary to shave the scalp, but the hair should be neatly parted over them, all grease removed from the scalp, which is next thoroughly disinfected with a bichloride solution. An incision is then made down to the wall of the tumor, when it

can usually be enucleated without difficulty. It is very important to leave none of the cyst-wall behind, or the tumor will be reproduced. A simple bichloride dressing and a bandage complete the operation. Unless the tumor is large, neither drainage nor sutures are necessary. Usually the wound will be entirely well in three or four days.

2. **Fatty Tumors** occur rarely in the scalp, and are very difficult to diagnose from the sebaceous, as they resemble them in almost all respects. They are apt, however, to be somewhat flatter and less globular, and also to be situated more deeply than the sebaceous tumors, not uncommonly being next the pericranium. An error in diagnosis is of no importance, however, as the treatment is identical—extirpation.

3. **Congenital Cysts and Fibromata** may occasionally occur in the scalp. The diagnosis is perfectly clear, and the treatment equally so—entire removal.

4. **Warts and Horns** are not uncommon. Horns should be removed by the knife. Warts, when they are inconspicuous and non-irritating, may be disregarded, but if they show the least tendency to grow they should be removed by the knife, as they sometimes become malignant.

5. **Moles** are a local hypertrophy of the skin. There are two forms: first, the *hairy mole*, covered with more or less stiff, bristle-like hairs, and without discoloration of the skin; and, second, the *pigmented mole*, in which the skin is discolored and of a brown or black tint. Sometimes they are of sufficient size to become serious disfigurements, and must then be removed by the knife after local anæsthesia by cocaine. If very large, sometimes either transplantation of skin or a plastic operation may make good the defect produced by their removal.

6. **Pneumatocele**, or a tumor filled with air, is very rarely met with. Treves states that only ten cases are on record. It is most frequently a result of spontaneous atrophy of the osseous tissue producing a communication with the mastoid cells. The air then escapes under the pericranium, forming a tumor which may vary in size up to that of a pigeon's egg. It is painless, elastic, smooth, and tympanitic to percussion. Pressure will ordinarily obliterate the tumor. The treatment is usually compression after emptying the sac of its air by pressure or by the needle of a hypodermatic syringe.

III. **Arterial Varix, or Cirroid Aneurysm.**—This is a peculiar dilatation of the arteries resembling the varix of varicose veins, but as it exists in arteries it is called arterial varix. It occurs most frequently in the scalp and the hand. The arteries become dilated, the middle coat especially undergoing atrophy, and are elongated and tortuous, like ordinary varicose veins. True aneurysmal pouches as large as the last joint of the finger or thumb are felt at various points. The whole mass pulsates synchronously with the heart, and a marked bruit is heard with the stethoscope (see Fig. 30).

There is no difficulty in making the diagnosis, but the treatment is much less satisfactory. Ligation of one or both carotid arteries has been done, but only occasionally has it been satisfactory. Excision has occasionally been resorted to, and is perhaps the best method, but it should be done only by an experienced surgeon, as it is apt to be very bloody and difficult. Hypodermatic injections of tincture of chloride of iron and of pure alcohol have both been successful, as has also galvano-puncture. Direct ligation all around the periphery by multiple ligatures tied over compresses of gauze has also proved successful. The ligature should be inserted by means of a curved Hagedorn needle, and should go all the way to the bone, in order to include the dilated deep branches. Subcutaneous ligation has been tried, the so-

called Barwell's scarless method, by a curved needle carrying the thread from point to point, being inserted anew at each point of exit and carried to the next point. This method can be adapted to the ligation of the aneurysm in sections, or if small the entire mass can be secured by one ligature. If not increasing and not a source of annoyance, it may well be let alone.

IV. Capillary Varix, Nævus, or Mother's Mark.—These are of two varieties: 1. One made up of capillary vessels of good size, presenting a small, *strawberry-like tumor*, somewhat elevated above the skin. Nævi of this variety are very apt to increase steadily in size until they become a serious danger from hemorrhage. They should be removed early in life, especially if they show any tendency to enlarge and invade the surrounding healthy skin. If they are small, the best way is to put a pin underneath them and strangulate them by means of a silk ligature, tied tightly under the pin, which prevents its slipping off. It is very important that the whole of the nævus shall be included in the ligature, and if it is too large to be thus included by the ligature and a single pin, it is better to insert two pins at right angles to each other; or a double ligature may be passed under a single pin, each half of the ligature being tied separately. Excision will sometimes answer the purpose where the nævi are small. When very large, however, they must be ligated in sections.

2. The *Port-wine Mark* is a nævus with very small capillary vessels, which very rarely tends to enlarge, but may in itself be a serious deformity by its color and its original large size. Its name describes very well its appearance. The best treatment is excision, and, as the tissues of the face are very elastic, such a nævus, even of considerable size, may easily be removed, leaving only a linear scar. If too large for this method, it may sometimes be destroyed by passing through its substance parallel threads of silk soaked in a tincture of chloride of iron or Monsel's salt. Or the nævus may be frozen a part at a time, cross-hatched with a cataract needle or knife, the hemorrhage arrested by steady pressure with blotting paper, this process being repeated from time to time. This is practically painless and leaves no appreciable scar. Escharotics and the cautery have also been successfully used. None of these methods, however, is as good as excision, since most of them leave unsightly scars.

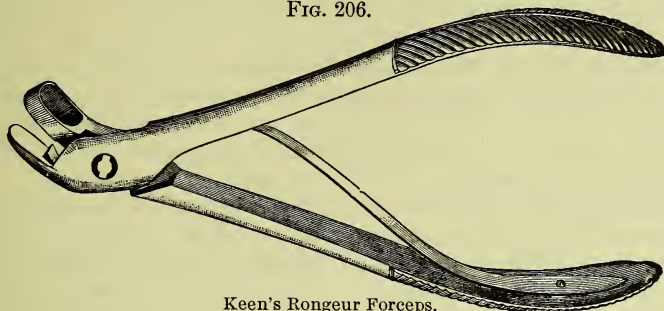
V. Lupus, the tubercular origin of which is now certain, is not so frequent on the scalp as on the face. It is a persistent ulcer, following tubercular infiltration of the skin, which gradually invades the surrounding sound structures and makes wide havoc. If small it may be excised: Koch's lymph seems to have had a beneficial influence in a number of cases. It may also be cured sometimes by thorough cauterization by Paquelin's cautery.

V.—DISEASES AND MALFORMATIONS INVOLVING THE SKULL.

I. Microcephalus.—Occasionally a child is born with complete ossification of the skull, even at the fontanelles, or the ossification may be completed soon after instead of at birth. While there is no doubt that, as a rule, the growth of the encasing hard parts is dominated by the growth of the contained soft parts, yet it is very possible that while a healthy brain may overcome the normal resistance of the skull, a brain with feeble powers of development may be arrested in its growth by the slight resistance offered by the skull. Accordingly, Lannelongue recently proposed to exsect a portion of the skull, about a quarter of an inch wide, extending from the forehead to the occiput. The excision, in order to allow more rapid expansion and growth of the brain, may be made on one side of the sagittal suture or

on both sides, may extend from the middle of the forehead well back into the occipital bone, and may have lateral branches, converting the side of the skull into a bony flap. The incision in the scalp should not go beyond the front line of the hair, so as to avoid any visible scar. By a transverse incision just behind this line the scalp may be displaced so as to give access to the frontal bone. The operation should be done on only one side at a time. Wyeth seizes the edges of the groove and forcibly separates them, a proceeding which would seem to be of doubtful utility, if not dangerous. To facilitate the operation Keen has devised a rongeur forceps (Fig. 206), which reduces the time of

FIG. 206.



Keen's Rongeur Forceps.

the operation to not more than twenty or thirty minutes, a very important element in diminishing the shock.

Whether the operation will stand the test of time is uncertain, but considerable initial improvement has followed in a small number of cases. Owing to the congenital weakness of such children about 20 to 25 per cent. die.

II. Periostitis, Ostitis, Caries, and Necrosis all occur in the bones of the skull as elsewhere. They very often follow injuries, are rarely tubercular in origin, and still more rarely may follow typhoid fever. By far their commonest cause is syphilis, which may make extensive ravages and destroy large parts of the skull. The dura seems in these cases to resist with singular power the extension of inflammation as a meningitis. Large portions of necrosed bone may lie on a bed of granulations springing from the dura, the inflammation being absolutely local and without any tendency toward a general meningitis. There will usually be either the history of an injury or the plain history of constitutional syphilis, with evidences of its existence in other parts of the body.

The **treatment** of all these conditions is the same as elsewhere. If pus accumulates, it must be evacuated as early as possible. If sinuses form, they must be opened speedily and be scraped and disinfected thoroughly. If caries exists, the bone must be laid bare and all carious bone removed with sharp spoon, gouge, and chisel. Necrosis may affect only the outer table or the entire thickness of the bone. The sequestrum and necrosed fragments must be entirely removed. In no part of the body is it more important to insist on frequent dressings, absolute cleanliness, and the securing, so far as possible, of an aseptic condition; otherwise the odor becomes almost intolerable. Corrosive sublimate, carbolic acid, iodoform, aristol, peroxide of hydrogen, and pyoktanin are all of use in attaining these ends.

III. Hypertrophy of the Bones of the Skull, with sclerosis and disappearance of the diploë, is a not uncommon result of osteitis deformans, and especially of hereditary syphilis, but usually requires no treatment.

IV. Atrophy of the Bones of the Skull is often seen as a simple

senile change. All the bones of the skull become thin and light, and even the base of the skull may become translucent or may be perforated as a result of the gradual thinning and absorption of the bones. When occurring in early life it was formerly thought to be especially the result of rickets, but later researches have shown it to arise more commonly from hereditary syphilis. The cranial bones may become so thin that they will crackle like parchment under very slight pressure. It is sometimes called *craniotabes*, and especially affects the occipital bone. A similar thinning sometimes occurs from brain-tumors.

The general treatment for inherited syphilis, together with cod-liver oil and the hypophosphites of lime and soda, etc., will sometimes produce speedy and very happy recovery. The child must be carefully protected from blows, falls, and other mechanical injuries.

V. Tumors of the Skull.—1. **Exostoses** sometimes occur as a result of injury, and if on the forehead become serious deformities. More commonly they are the result of syphilitic gummata, occurring therefore in the tertiary stage. They may arise on either the outer or the inner surface of the skull. If external, they are called exostoses; if internal, enostoses.

The treatment is that for syphilis of the bones. If external and a serious annoyance, they may be removed by the knife and chisel. If internal and productive of any serious lesion of the brain, the skull should be trephined and the mass removed. The difficulty lies in locating the tumor. Not uncommonly the development on the inside of the skull corresponds to a similar growth on the outside. Failing this, the only other indication of the internal tumor is the localizing symptoms in brain disease which are described later.

2. **Sarcoma** affects the bones of the skull in all of its three forms, round-celled, spindle-celled, and giant-celled. It may arise in the periosteum, the diploë, or the dura. If it develops to any size, it is accompanied with great deformity and in all cases with great danger.

The only proper treatment is excision by the knife, chisel, and saw, but this is usually unavailing in preventing relapses, and the operation itself involves such danger as often to be fatal, especially when, as is sometimes the case, the superior longitudinal sinus is involved. Except in very favorable cases, therefore, as a rule no operation should be attempted.

Sarcoma arising from the dura perforates the cranium and spreads sometimes widely under the scalp, and finally perforates it externally. It was known to the older writers as *fungus of the dura mater*. The diagnosis is best made by discovering the opening in the bone by touch and by the evidences of pulsation of the mass, its partial or complete reducibility, generally accompanied with symptoms of pressure, and the optic neuritis which often results from it. It may occasionally be removed, but will always recur, and is a fatal disease.

3. **Epithelioma** is occasionally seen, and is to be treated on the same principles as stated under Sarcoma.

VI.—DISEASES AND MALFORMATIONS INVOLVING THE BRAIN.

I. **Meningocele, encephalocele, and hydrencephalocele** are allied malformations of the brain which are fortunately not common.

1. **Meningocele** consists in the protrusion of the membranes of the brain through an aperture in the bones of the skull, the sac formed by the membranes being distended to a greater or lesser extent by fluid which is extra-cerebral.

2. **Encephalocele** consists in the protrusion of a portion of the brain itself, as well as of the membranes, usually with a smaller amount of fluid in it, the fluid again being external to the brain substance.

3. **Hydrencephalocele** consists in the protrusion of the brain substance itself as well as of the membranes, but in this case the interior of the mass communicates directly with the ventricles, and is often filled with a large amount of the ventricular fluid, so large in some cases that the layer of brain substance enclosing the fluid is reduced to a very thin film.

All three forms of the disease arise in intra-uterine life, and are therefore congenital. The most frequent is unfortunately the gravest form—viz. hydrencephalocele—and the least frequent is meningocele. As a rule, they are apt to be fatal early in life. Their commonest situation is first in the median line, especially in the occipital region; next, the fronto-nasal; and lastly, the sides of the skull or about the base. Of 93 cases collected by Houel, 68 were occipital, 16 fronto-nasal, and 9 at the sides and base.

Diagnosis.—They have been mistaken for abscesses, nævi, sebaceous cysts, etc. The following points of diagnosis will generally enable the surgeon to reach a proper conclusion:

All of them are congenital, commonly median, and especially occipital in position. *Meningocele* is usually cystic in its feel, is translucent, fluctuates, rarely pulsates, is more or less pedunculated, generally becomes tense in forced expiration, and is easily reducible. *Encephalocele* is usually small, is opaque, does not fluctuate, pulsates distinctly, has a wide base, becomes more tense in forced expiration, and symptoms of pressure are produced on attempting to reduce it. *Hydrencephalocele* is generally large, is lobulated, is partially translucent, fluctuates distinctly, pulsates but rarely, is usually pedunculated, is made only slightly more tense in forced expiration, and is not reducible.

All three forms are apt to be combined with other deformities, and paralysis often accompanies hydrencephalocele.

Treatment.—As a rule, hydrencephalocele is not amenable to treatment. The child, fortunately, dies early. The other two forms hold out more hope, especially if they are small. Sometimes an encephalocele by retrograde development may be changed into a meningocele, and occasionally by gradual concentric ossification, resembling that of the fontanelles, the bony aperture is lessened and may even be closed. The intracranial communication with the interior of the sac may be narrowed and finally obliterated, thus partially or completely effecting a spontaneous cure. Until the late improvements in cerebral surgery nothing was usually recommended in the way of treatment, certainly not unless there was danger of rupture. A number of successful cases of excision, however, have been recently reported, and, unless the size of the tumor or the condition of the patient forbid, this should be attempted, of course with all the antiseptic care bestowed on all other brain operations. Enough scalp should be preserved to make sufficient flaps to close the opening. If operation be thought inadvisable, electrolysis may be used as a substitute. Pressure and the injection of Morton's fluid (iodine gr. x, potass. iodid. gr. xxx, glycerin ʒj) may be tried, but with little prospect of benefit.

II. **Hydrocephalus**, or dropsy of the brain, exists in two forms: 1. **Acute hydrocephalus**, which is usually the result of meningitis, especially of tubercular origin. It consists in an accumulation of fluid which is occasionally extra-ventricular, but more commonly is in the ventricles themselves. There will usually be headache, fever, more or less stupor or delirium, with symptoms of pressure, producing strabismus, rigidity of the muscles of the neck, twitching of the muscles of the face or of the extremities, and convulsions, followed by paresis or paralysis of one or more members. As a rule, optic neuritis will be present. Generally nothing will check the progress of the disease. Tapping of the ventricles has been done in several instances, but without success except

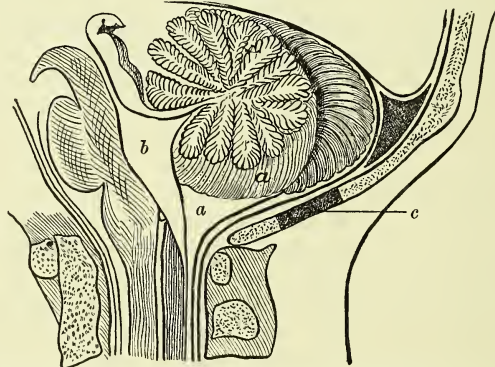
in one non-tubercular case of Mayo Robson's. Success must necessarily be rare, but every life saved is one rescued from otherwise certain death.

2. **Chronic hydrocephalus** is entirely different in its origin and course. It is usually congenital, although it may not be observed until some months after birth. The first symptom is enlargement of the cranium, which goes on until the bones become separated from one another. The protuberant forehead gives a characteristically strange facial expression. The child very rarely becomes able to walk or to talk. The sight is often affected, intelligence is absent, and convulsions are common. The post-mortem will show enormous distention of the ventricles, so that the brain consists merely of a soft bag of cerebral substance distended with cerebro-spinal fluid. Fortunately, most such defectives die early, but occasionally they live even to adult life.

The **treatment** is unsatisfactory and usually unsuccessful. Pressure does but little good. Tapping has been done by two different methods. First, by a fine trocar the ventricle has been punctured through the widely-dilated anterior fontanelle. This puncture should be made away from the middle line, so as not to puncture the superior longitudinal sinus. Not more than two or three ounces of the fluid should be evacuated, for the removal of large quantities, and very often even of small ones, is followed by convulsions and death. Occasionally larger quantities have been removed successfully. In this case pressure must be carefully maintained during and after the operation. Second, when the ossification of the skull is complete, tapping the lateral ventricles has been done, but so far without success. Quincke has recently proposed the tapping of the theca of the lumbar spinal cord, thus draining the ventricles at a distance, while pressure is made on the skull.

Parkin has suggested in place of lumbar puncture to substitute puncture of the subarachnoid space under the cerebellum. He reports 4 cases with

FIG. 207.



Vertical Section of Base of Skull immediately to the right of the Median Line: *a*, basal subarachnoid cavity and its relation to the cerebellum; *b*, fourth ventricle; *c*, site of trephine aperture (*Lancet*).

2 recoveries, and Ord and Waterhouse record another recovery from an almost certain tubercular meningitis. The occipital bone is trephined. The dura is opened, the cerebellum lifted, and the subarachnoid space punctured by a grooved director or other similar instrument (Fig. 207).

VII.—INJURIES OF THE HEAD.

I. **Cephalhematoma**, or **Caput Succedaneum**, is a soft tumor usually in the parieto-occipital region in new-born children. It consists of an accumu-

lation of blood and serum under the scalp, the result especially of prolonged labors and consequent mechanical injury to the scalp. Generally no treatment is necessary, as the mass is, as a rule, absorbed within a few days after birth.

II. Wounds of the Scalp.—These differ in no respect from wounds elsewhere in the body, except that wounds of the scalp are more prone to erysipelatous inflammation and abscesses than wounds of the skin in other parts of the body, unless the greatest care is taken in their proper treatment.

The blood-supply of the scalp is so abundant that even a slight pedicle of attachment is sufficient to ensure the vitality of a large flap. Hence in lacerated wounds an attempt should be made to save most of the torn pieces unless absolutely detached. In any wounds, except very small ones, in order to ensure disinfection the scalp should be shaved over a very wide area. Even in women appearance must give way to safety. It should then be thoroughly disinfected by the removal of all dirt and other foreign matters by rubbing in sweet oil, then washing well with soap and water, following this by a thorough scrubbing with a bichloride solution 1:1000, trimming off the infected edges if the wound is lacerated, and lastly by accurate suturing. The bleeding vessels will require ligation only when exceptionally large, provided the hemorrhage has been arrested by crushing the vessels in the jaws of hemostatic forceps. The forceps may seize the entire thickness of the scalp with impunity. If these precautions are taken, usually no drainage will be necessary, but should there be necessity for it a few strands of disinfected horsehair will answer the purpose. These should be removed in a day or two. Silkworm-gut interrupted sutures may be used. A large sublimate dressing may then be applied and retained in place by an ordinary recurrent bandage. The most important point in such wounds is the careful and wide disinfection. They will then follow the usual aseptic course of other wounds. If this be neglected, even small wounds have a large reserve of danger.

III. Abscess of the Scalp is first a consequence of inflammation, often of an erysipelatous character, and occasionally it is a sequel of typhoid fever; secondly, it is a sequel of contusions; and thirdly, it often follows wounds the edges of which have been closely coaptated without sufficient preliminary disinfection. Very often such patients are first treated in drug-stores, where usually a very elaborate stellate dressing of adhesive plaster is put on without any attempt at disinfection. All such dressings should be removed at once and the wound re-dressed after proper disinfection.

Abscess is accompanied usually with pain of a throbbing character and inflammation of the scalp, which is almost always erysipelatous in appearance, though it may not be caused by the microbe of erysipelas. Not uncommonly there is marked oedema of the surrounding parts, which if it extends to the eyelids produces blindness mechanically by the swelling of the lids. There is almost always pitting on pressure. The constitutional symptoms are marked and sometimes very severe, the fever running high and being accompanied not infrequently with delirium. The chief dangers here are that the pus may burrow widely; if under the aponeurosis of the occipito-frontal muscle it will be limited by the attachments of this muscle and its aponeurosis, and the location of the effusion can thus be readily diagnosticated; and if it be under the pericranium, and sometimes even if it be more superficial, that the inflammation may extend to the brain through the vascular perforations in the skull and cause meningitis. Occasionally it may produce necrosis of the bone.

The treatment is very clear. As soon as the abscess is diagnosticated a free incision should be made at what will be the most dependent point in

the recumbent posture, with disinfection of the wound as far as possible, and drainage.

IV. Contusions of the Head are very common as a result of falls, blows, etc. They may be slight or severe. After a slight contusion the patient is more or less stunned, and swelling very quickly follows, due chiefly to hemorrhage under the scalp. This hemorrhage is very apt to give the impression of depressed bone, and may mislead one into supposing that there is a fracture, the hard ridge on the curved edge of the swelling being mistaken for the edge of the depression. But after a simple contusion this ridge is elevated considerably above the general contour of the head, the edges are rounded, and pressure will not uncommonly cause pitting. If there be fracture with depression, the edge is usually about on a level with the surrounding skull or below it, and the margin is sharper, more irregular, and less circular.

Ordinarily pressure, with perhaps some cooling lotion, as simple tincture of arnica or lead-water and laudanum, will cause the major part of the swelling to disappear within twenty-four hours. Rather rarely, however, abscess will follow.

If the contusion be somewhat more severe, the bone may become involved, producing sclerosis as a result of the chronic inflammation, or if the blow be sufficiently severe to destroy its vitality even necrosis may follow, although this is a comparatively rare result. Severe contusions may involve the brain itself. These are described under the next head.

V. Concussion or Laceration of the Brain.—The term “concussion” of the brain is an unfortunate one, as it conveys the idea of a functional rather than an organic lesion. While there may be slight injuries of the brain that may in this sense be properly called concussions, it is far better to consider concussion as usually equivalent to *laceration* of the brain tissue.

The brain may be injured either by direct or by indirect force. A blow on the head is an example of direct force; an instance of indirect force is a fall in which the patient lights fully upon his feet or sits down upon his buttocks. What happens in such cases is best explained by an experiment made by Felizet. He filled a skull with paraffine and dropped it on the floor. On opening the head no fracture was found, but at the point of impact the bone had been driven down upon the paraffine and flattened it, and, while the bone had sprung back to its original position without fracture, the flattening of the contents remained. Had the skull been living and filled with brain tissue, the same depression and temporary compression of the brain would have taken place; and we can scarcely imagine that such an amount of mechanical disturbance of the brain can occur without more or less laceration of brain tissue and rupture of blood-vessels, followed by some slight hemorrhage. Moreover, as Duret has shown, the wave in the cerebro-spinal fluid created by a blow produces what is often its maximum effect on the opposite side of the skull from the point struck, tearing the vessels of the pia and the cortex. This undoubtedly explains injuries of the brain by so-called *contrecoup*, or counter-stroke. Miles has shown experimentally that at the point of impact there is a “cone of depression,” accompanied by a “cone of bulging” at the opposite pole, thus confirming Duret’s observations. If the cone of bulging is sufficiently ample, a fracture may be produced.

The patient who has received such an injury, if it be slight, will perhaps lose his balance and fall, become pallid, confused, and giddy, and may be nauseated and even vomit, but after a period of rest he will gradually recover. If, however, the injury be more severe, there may be grave laceration of the brain or of its membranes, or of both, and the patient will fall and lie quietly,

with a feeble, fluttering heart, cold, clammy skin, and apparently be unconscious. He can usually, however, be aroused by shouting and loud questioning, but will reply in monosyllabic answers or unintelligible sounds. He will not be paralyzed, but may move the extremities, which will not have lost entirely their sense of feeling. Not uncommonly urine and feces will be passed involuntarily. The pupils will vary, being either contracted or dilated to a moderate extent, and possibly unequally, but, as a rule, they will react to light. Occasionally convulsions occur. As he reacts he will very probably vomit. Usually within twenty-four hours or more his condition as to consciousness will become better, but he will suffer from considerable headache, lassitude, and indisposition to exertion. After partial recovery, and sometimes for a long period, he will suffer more or less with vertigo, headache, and indisposition to mental exertion. Occasionally more serious results will follow, even after a long interval, and abscess of the brain should be especially watched for. Sometimes epilepsy or insanity may follow. If the patient, instead of recovering, grows worse, either coma will set in or the symptoms of meningitis or encephalitis as described below.

Prognosis.—The uncertainty as to the degree and even the character of the cerebral injury should make us especially careful as to prognosis and treatment. Any contusion which has been severe enough to produce unconsciousness should be considered a serious injury, for we may be sure that there has always been such an amount of laceration as to make serious danger a possibility and often a probability.

Treatment.—As soon as possible the patient should be placed in bed without any pillow, and his body surrounded with hot-water bags or hot-water bottles suitably protected. He should be kept quiet and as free from the excitement of conversation or business as possible, and restful sleep should be encouraged. Aromatic spirit of ammonia during the period of shock is better than alcohol, for the excitement of alcohol, which is quickly felt in the brain, should be avoided. Hot water or ice water, as may be most agreeable to the patient, may be given. A careful diet, with occasional purgatives, and attention to the general hygiene are necessary for days or weeks.

In case inflammation of the brain supervenes, surgical opinion is at present somewhat divided as to the proper course to be pursued. Many surgeons, perhaps the majority, would treat it as an Encephalitis (see p. 518) and not trephine; others, on the contrary, believe that if serious symptoms arise, indicating intracranial mischief, especially if this be localized, a semicircular flap of scalp should be raised over the seat of the injury and the bone inspected. If an unsuspected fracture is discovered and the symptoms are serious, showing meningitis or encephalitis, an exploratory trephining should be done and the dura opened. Once such inflammation with its attendant proliferation and exudation has begun, it is essential in their view that a means of escape for the exudate be provided before the inflammation shall have proceeded so far as the production of dangerous pressure or even of suppuration itself. In other words, they would treat contusion followed by symptoms of serious intracranial mischief precisely as they would treat such injuries in other parts of the body; always remembering that in the brain there is no possible means of escape for the hemorrhage or exudate without surgical assistance, because of the bony case in which it is retained; but remembering also that while trephining is equivalent to incision down to the injury in any other part of the body, yet that it is always a grave operation and never to be undertaken without earnest reflection and good reason.

In many cases of severe contusion it is proper immediately (with all the

antiseptic precautions so often insisted on) to raise a horseshoe-shaped flap in order to determine at once the question of fracture, as the swelling of the scalp if this be thick or very dense makes it difficult without such an incision to ascertain whether fracture exists or not. The objection that if a simple fracture exists by such an incision we convert it into a compound one no longer holds good, for a simple incision through the scalp is not attended with grave danger in these days of antiseptic surgery, and the very slight dangers of the wound are as nothing compared to a certain diagnosis and suitable treatment.

After the patient has recovered from a severe contusion or laceration of the brain he should not be allowed to return to business or other occupation for at least a number of weeks, or even for a longer period; and if at any time he shows indications of hebetude or is attacked by headache, especially if accompanied with little or no rise of temperature or even a somewhat subnormal temperature, an abscess should be suspected and its symptoms watched for. (See Abscess.)

After severe concussion of the brain the patient sometimes passes, in the course of a few hours or more, into a peculiar condition well termed by Mr. Erichsen *cerebral irritability*. Instead of recovering consciousness, he is apt to lie on his side, with his eyes closed, his legs drawn up, and his back curved. The pupils are contracted, but respond to light. If disturbed, he is restless and irritable or may even show some delirium. He may answer questions sometimes in a vexed way, or may refuse to respond. There is sometimes no rise of temperature, either general or local, and it may even be subnormal. The pulse is weak and slow. Not uncommonly the bowels and bladder are evacuated involuntarily, though sometimes the patient will indicate his wants. Recovery will usually take place slowly, with no recollection of his condition or conduct. Occasionally, however, the mental faculties will not recover. The treatment for this irritability must necessarily be a symptomatic one.

VI. Compression of the Brain.—The surgical causes of compression of the brain are intracranial hemorrhage, tumor, depressed fracture, foreign bodies, and the products of inflammation. Hemorrhage and inflammatory exudate produce the symptoms of compression almost immediately when they are sudden and severe, but if the blood or exudate accumulate gradually, the compression symptoms will arise as soon as the amount of blood or pus becomes large. In very slight but steadily increasing hemorrhage or a slowly-forming abscess the brain accommodates itself for a time to the gradually increasing pressure. Even considerable depression of the bone may for some time be followed by no symptoms of compression.

Symptoms.—In compression unconsciousness is complete. The patient lies supine and does not move, or if he moves it will be an occasional restless change of place of an arm or a leg. He will not respond to any questioning or to the loudest shouting in his ear. The pupils are dilated and do not respond to light, the breathing is slow and stertorous, with a peculiar puffing respiration, due to expiratory distention of the cheeks and lips, the facial muscles being paralyzed. The skin is usually hot rather than cold, and is covered with a profuse perspiration. The pulse is slow, full, and often irregular. The bladder and bowels are, as a rule, paralyzed: hence the urine is not voided until the bladder becomes over-full, when the incontinence of retention sets in. Sometimes the whole body is paralyzed, though hemiplegia is more common. If the lesion is limited and not too large, the paralysis will be limited, for example, to a monoplegia, that is to say, paralysis of one arm or one leg or one side of the face, if the cause of the compression is limited to one of the cortical centers supplying these regions. The significance of such

a localized paralysis is extremely valuable in the diagnosis of the seat of the lesion; and if the paralysis begins in one part of the body and spreads to other parts, the cortical centers of which are adjacent to the center for the part first paralyzed, the diagnosis may be regarded as positive.

If the cause of the compression is *hemorrhage* in the interior of the brain—*e. g.* from the lenticulo-striate artery, the “artery of cerebral hemorrhage” of Charcot—unconsciousness usually occurs instantaneously or almost so. If it is from a rupture of the middle meningeal artery, a point of the greatest importance in the diagnosis is that after the reception of the blow there is a period of consciousness corresponding to the period of time necessary for the escape of a sufficient quantity of blood to produce unconsciousness from pressure. If a small branch of the middle meningeal is ruptured, the period of consciousness may be comparatively long, even several hours, occasionally a day or more; but if the main trunk is injured, the blood pours out so rapidly that only a few minutes may pass before unconsciousness supervenes.

If caused by fracture or foreign bodies, the symptoms of compression usually follow immediately upon the reception of the injury, but occasionally they may be delayed for some hours. If caused by inflammation and the formation of pus, the symptoms of course will develop only when the pus accumulates in sufficient quantity to produce serious pressure. This development of pressure symptoms in these cases is usually gradual, the mental dulness deepening into coma, but sometimes it is, as it were, by a sudden explosion. If tumor is the cause, the brain may accommodate itself for some time to a slowly-growing tumor, but if it grows rapidly symptoms of compression will set in at an early date. Optic neuritis will generally develop at an earlier or later date.

Diagnosis.—The principal conditions which must be diagnosticated from injuries of the brain producing compression are *alcoholic intoxication*, *opium-poisoning*, *apoplexy*, and *uremia*. If a man is picked up in the street by the police and is carried to a hospital without any previous history, the surgeon must be on his guard lest he mistake any one of these four conditions for a serious injury to the brain. In *cerebral injuries* there will usually be an evidence of the accident in a bruise or cut, though of course the man may have fallen when intoxicated or have been suddenly attacked by apoplexy and in falling have received a more or less serious wound. In *intoxication* the accident will usually be comparatively slight. Possibly his appearance, giving evidence of intemperate habits, may be some guide to diagnosis, but this may easily mislead us. His breath may be alcoholic, but it must be remembered that alcohol may have been given to the man to revive him after serious brain injury. A drunken man, although stupid, is not unconscious, nor is he paralyzed or hemiplegic. His pupils are not dilated as in compression, but are more commonly contracted, dilating when any attempt is made to rouse him. The temperature is generally subnormal.

In *apoplexy* there are absolute unconsciousness, stertor, and hemiplegia or complete paralysis. In *opium-poisoning* the pupils are contracted to pin-points and will not dilate, and there is no paralysis. In *uremia* paralysis and stertor are absent, unless there is apoplexy, and there is apt to be œdema of the legs, and if the urine be examined there will be found undoubted evidences of albumin. The eye-ground should be examined in all cases, as it may throw considerable light on the nature of the case. If, after all, the case is doubtful, it should always be treated as one of cerebral injury.

Prognosis.—If the compression is caused by extravasated blood, the patient has a fair chance of recovery after trephining, evacuation of the clot, and arrest of the hemorrhage. If it is caused by depressed fracture, and the

proper operative relief is afforded, his chances of life will vary with the degree of severity of the injury. In cases of foreign body in the brain the prognosis, as a rule, must be unfavorable; and the same may be said of tumors and inflammation with internal hydrocephalus.

Treatment.—The diagnosis of compression having been established, the treatment will vary with the cause. If it is from hemorrhage, the treatment must be the speedy relief of the pressure by evacuation of the clot and arrest of further bleeding by ligature, as mentioned in the next section. If it is from depressed bone, trephining should be done at once with all the precautions heretofore described, and the bone elevated or removed as may be found necessary. If from foreign bodies, these should be removed, with the limitations stated in the section treating of that lesion. If from an abscess in the brain, trephining should be done and the abscess evacuated and drained. (See Abscess of the Brain.) If serum has accumulated either in the ventricles or in the subarachnoid space, trephining should be done and the exudate drained, even by puncture of the ventricles if necessary. If the compression is from tumor, the tumor should be removed if the case is suitable.

In all cases the utmost care must be observed as to the later treatment by rest, the most restricted liquid diet, attention to the bowels and bladder, and the general precautions mentioned in connection with Meningitis and Encephalitis.

VII. Intracranial Hemorrhage.—This may be either spontaneous or traumatic. Though there is at least one case of apparently spontaneous rupture of the middle meningeal arteries, yet as a rule spontaneous hemorrhage into the brain occurs in connection with the lenticulo-striate artery distributed to the ganglia at the base. The clot usually forms either in these ganglia or in the white substance of the centrum ovale, and produces the familiar forms of apoplexy, the consideration of which belongs to medicine rather than to surgery. Richardière has shown that one of the most frequent causes of the death of newborn children very shortly after delivery is meningeal hemorrhage from the rupture of the vessels at the moment of birth as a result of traumatism to the foetal head in its passage through the pelvis.

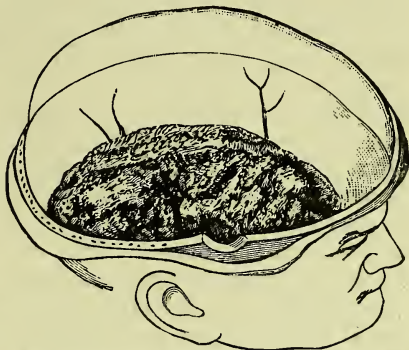
Hemorrhage from Traumatism may occur in three positions: it may be (a) extradural, that is, between the dura mater and the bones; (b) subdural, that is, between the dura and the brain; (c) cerebral, that is, into the brain tissue itself.

(a) **Extradural Hemorrhage.**—This is almost always caused by the rupture of the middle meningeal artery or its branches. The violence which may rupture this artery is, as a rule, considerable, although it may be so slight as to leave no bruise. Fracture will frequently exist, though in a considerable percentage of cases there may be no fracture whatever; but commonly it is present, and extends not only over the vault, but also to the base of the skull. It will be remembered that the middle meningeal arises from the internal maxillary and enters the cranium at the foramen spinosum, quickly dividing into an anterior and a posterior branch. The anterior branch, after running in the groove in the wing of the sphenoid, reaches the parietal bone at its anterior inferior angle, whence it passes upward toward the middle line. The posterior branch, after running over the posterior part of the squamous portion of the temporal bone, also reaches the parietal bone. The main trunk of the artery is rarely ruptured; the two branches are far more frequently the site of this lesion (Fig. 208).

The **symptoms** of such hemorrhage are of great importance, for while formerly in these cases the surgeon stood by with his arms folded and watched his patient die, the last few years have taught us that a large proportion of such

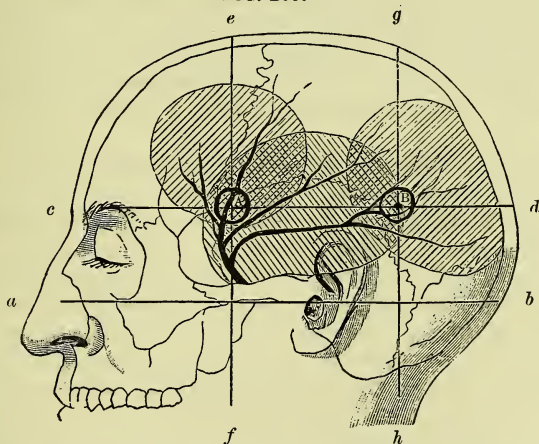
cases may be saved by prompt interference. The accident may stun the patient and may produce a brief period of unconsciousness. From this he recovers only to relapse anew into unconsciousness. This *period of consciousness* between the accident and the appearance of the persistent coma is of the greatest importance and worth all the other symptoms put together. It is due to the fact that a certain amount of time must elapse before the quantity of blood which escapes is sufficient to produce unconsciousness from pressure. If the main trunk or one of the larger branches is ruptured, the blood escapes rapidly, and this period of consciousness will be very brief; but if one of the smaller branches is ruptured the interval may be one of hours or even days before a sufficient clot accumulates to produce it. The possible existence of this interval of consciousness should therefore be inquired into in all cases, and if there be other signs of intracranial hemorrhage the diagnosis will be clear. These other signs may be, (1) Hemiplegia, on the side opposite to the hemorrhage. The hemorrhage, while usually on the same side as the injury, may take place upon the opposite side, in which case the hemiplegia and the wound will be on the same side. Moreover, the paralysis is apt to be progressive, extending from one part of the body to another, as the widening clot produces pressure on one cortical center after another. For instance, the clot may begin over the face center, producing paralysis of the face; then it extends upward to the arm center, and the arm

FIG. 208.



Hemorrhage from the Middle Meningeal Artery (Jacobson).

FIG. 209.



Site of Trephine Opening to reach Clot in Hemorrhage from Middle Meningeal Artery (Krönlein): *a, b*, horizontal line through the meatus; *c, d*, on a line with the eyebrows; *e, f*, vertical line 3 to 4 cm. behind the ext. ang. process; *g, h*, at the posterior border of the mastoid process. *A*, the point to reach the anterior, and *B*, the posterior branch (Esmarch and Kowalzig).

will be paralyzed; and finally, as it reaches the leg center, the leg will be paralyzed. Rarely the artery may be ruptured on both sides. (2) If the clot, instead of extending upward, gravitates toward the base, the pupil on the side of the clot will be dilated and immobile, and if on the left side aphasia

will appear. (3) The pulse becomes frequent. (4) Respiration is slow and stertorous. (5) The temperature will probably rise to 101° to 103° , or even 104° F., especially on the side opposite the clot. (6) In a compound (especially in a gunshot) fracture, with a perforation of the skull and the meninges, blood may escape in such quantity and with such rapidity as continually to force the brain-substance out of the wound.

Treatment.—As soon as the diagnosis is well established, operative treatment should be resorted to as quickly as possible. Wiesmann has best shown the importance of this, for of 147 cases treated expectantly, 131 (89.1 per cent.) died, while of 110 cases operated on, only 36 (32.7 per cent.) died, and in the majority of the fatal cases the extravasation was not reached and the clot therefore not removed. In operating we should determine the question which side of the skull should be trephined, *not by the site of the injury, but by the localizing symptoms*. In far the greater number of cases, as shown by Krönlein, the clot will be best reached by trephining one inch and a quarter behind the external angular process at the level of the upper border of the orbit. (Fig. 209, A). Should the clot not be revealed by this opening, we should immediately trephine again, just below the parietal boss, on the same level as the former opening (Fig. 209, B). By the anterior opening the main trunk and the anterior branch of the middle meningeal artery may be reached, and by the posterior opening the posterior branch. In many cases, of course, it is very doubtful which branch is ruptured; hence the need for the second opening if the first does not disclose the clot. The clot should now be removed, either opening being enlarged, if need be, by the rongeur forceps in order to gain access to it. If the pupil is dilated, and evidence given therefore that the clot is gravitating toward the base, the trephine opening should be made near the first point, but about half an inch lower. The clot should be scooped out very gently, and the cavity in which it has lain should be well washed out with sufficiently cooled boiled water. If the artery is still bleeding, a catgut ligature should be passed through the dura, under the artery, and out again through the dura on the other side of the artery, by a semicircular Hagedorn needle, and the artery tied. Drainage should be carefully provided, and the wound then treated as usual. If the first trephine opening does not answer well for drainage in the recumbent posture, a second one should be immediately made.

(b) **Subdural Hemorrhage.**—This hemorrhage will occur most frequently as a result of depressed fracture and rupture of a number of small vessels, or it may be of one large vessel (especially the middle cerebral), the contents of which pour out under the dura. The symptoms will be much the same as those mentioned in connection with hemorrhage from the middle meningeal, and at present there are no means of distinguishing between hemorrhage from the middle meningeal and that from the middle cerebral. It is, however, of no great practical importance to distinguish between them, for the treatment is the same. The anterior trephine opening before referred to, especially if enlarged upward and backward, will give access to the middle cerebral, and if the evidences point to intracranial hemorrhage, and on trephining no clot is found under the bone, the dura should be opened and the clot searched for on the surface of the brain itself, following the direction of the fissure of Sylvius, in which the middle cerebral lies. If this be the source of the hemorrhage, the bleeding point must be found and the artery ligated. More commonly, however, subdural hemorrhage is caused by the rupture of a number of vessels under a depressed fracture, and the consequences, unless the case is properly treated, are most deplorable. Not uncommonly the patient will die as a result

of the injury to the brain; but should he recover the course of events is usually as follows: The clot, having produced more or less extensive paralysis, is gradually absorbed, but the brain may not expand to its former position, being permanently depressed, for the site of the injury is sometimes occupied by spongy connective tissue the meshes of which are filled with cerebro-spinal fluid, resembling a series of cysts. The paralysis will gradually lessen and may almost entirely disappear. After a varying interval, from a few months up to two or three years, the patient may, however, become subject to epileptic or other cerebral disturbances, and if so he will lead a miserable existence so long as he may live. The importance, therefore, of evacuating the clot, removing the pressure, and thus preventing the disastrous later effects, is evident. Hence all cases of marked and localized depressed fracture should be trephined, the bone lifted, and the clot evacuated and treated as has been described.

Hemorrhage from Pachymeningitis Interna.—A few cases have been reported of subdural hemorrhage from pachymeningitis interna. These are amenable to the same treatment, by trephining, evacuation, and drainage. Even so long as two months after the accident Ceci has been able to rescue his patient from a condition of complete coma and palsy, with almost total restoration of function.

(c) *Hemorrhage into the Brain Substance.*—Severe traumatism may rupture the vessels in the interior of the cerebrum, and even produce hemorrhage into the ventricles. The symptoms in this case will resemble those of ordinary apoplexy in every respect except the cause. The diagnosis is based upon this resemblance and this difference. As a rule, little can be done in such cases, for the injury to the brain substance is generally so extensive that even if the clot be evacuated the patient will usually die from the injury.

(d) *Wounds of the Sinuses of the Brain.*—Occasionally in operations, but more commonly from severe and usually compound fracture, the superior longitudinal or the lateral sinuses of the brain may be injured. It is always a serious and often a fatal accident. The blood pours out so furiously that the patient may die in a few minutes from the shock of the injury; for undoubtedly rapid loss of blood from the brain itself is more fatal than the loss of an equal amount of blood from any other part of the body. Hence all operations in the neighborhood of the sinuses should be conducted with great care. If necessary to trephine in their neighborhood, the edge of the trephine should be at such a distance as to be perfectly safe. With the dural separator or a grooved director or probe, and then the finger, the dura may be separated and the sinus entirely detached from the skull; and then the original trephine opening can be safely enlarged at will by the rongeur forceps. If necessary, a portion of the sinus may be removed by first exposing it in the manner indicated, and then ligating it on both sides of the proposed incision. Should the sinus be ruptured either in an operation or by a fracture, the hemorrhage usually can be controlled by instant packing with iodoform gauze. Sometimes the margins can be seized by one or more pairs of hemostatic forceps, which may be removed on the second or third day. Of course great care should be taken lest they be displaced in the tossing of the head by the patient. Lateral ligature and suture of the sinuses have also been employed.

VIII.—FRACTURES OF THE SKULL

Fractures of the skull are considered with injuries of the head rather than with other fractures, for the reason that the fracture *per se* is of comparatively small moment. By far the most important factor in such injuries is the injury to the brain or to its membranes, or to both. A violence that will break the bones of the head is such that, even though there is no depression, very often the brain itself suffers serious injury; and if fragments are depressed or broken off and driven into the brain, the injury becomes even more severe and often fatal. The treatment of such fractures, therefore, is based on the injury, either actual or possible, to the brain itself, rather than on the injury to the skull. The history of such fractures and of their treatment is almost like that of abdominal diseases and injuries. The hesitation to interfere which prevailed in the past has been happily replaced by positive action of the most radical character, so that the treatment of such fractures has been almost entirely changed within the last ten years. The danger is now perhaps in the opposite direction—that surgeons may go too far and do harm rather than good by a rash interference instead of a wise conservatism.

Fractures of the skull are very frequent as a result of falls, blows, either from falling bodies or in personal encounters, and similar accidents. They are often extensive and involve wide areas of the skull in multiple fractures; or, on the contrary, they may be limited to a very small area, as in punctured fractures made, for instance, by a knife-blade or a nail, in which, as a rule, there lurks even more danger than in the more extensive fractures, because they are so apt to be improperly treated. The same varieties that are found in fractures elsewhere obtain in the skull. The fracture may be either simple or compound. If simple, the fracture in the bone does not communicate with the external air; if compound, it does, usually through the lacerated scalp. But attention is especially called to the fact that a fracture of the skull which extends into the nose, ear, or mouth is just as truly compound as a fracture of the vault, and even more dangerous, because the fact that it is a compound fracture, and therefore liable to infection, is so often overlooked. Such fractures, again, may be impacted. They may also be partial; that is, the outer table may not be broken, yet fragments may have been broken off from the inner table, wounding either the meninges or the brain itself.

Fractures of the skull are best discriminated by their position as fractures of the vault and fractures of the base of the skull. Fractures of the vault are usually the result of direct violence, while fractures of the base result either from the extension of fractures of the vault from the side to the base of the skull, or from indirect violence, such as a fall in which the person may alight upon the feet or the buttocks, in which case the blow is delivered through the spinal column, and sometimes even a fall on the vertex, in which, either with or without fracture of the vault, the base is fractured in a similar manner by the weight of the body. The base has also been fractured by violence received through the lower jawbone, the condyles having even been forced within the cavity of the skull.

Fracture of the skull sometimes, but very rarely, occurs at a point opposite that at which the blow is received. This is called fracture by *contre-coup*, or counter-stroke. Rupture of the meningeal vessels and of the brain itself certainly does take place at such a point not uncommonly, and its mechanism has already been explained (p. 498).

Fig. 1.

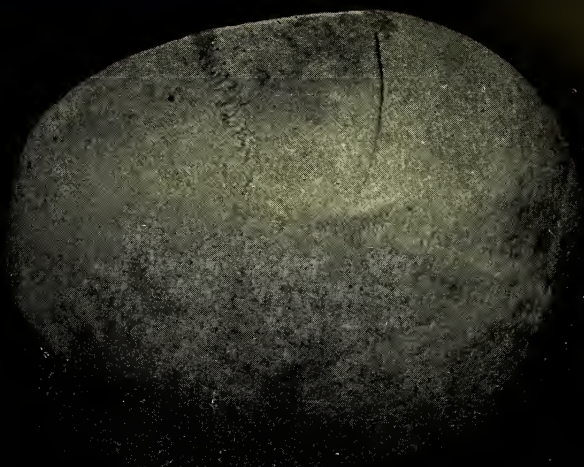


Fig. 2.

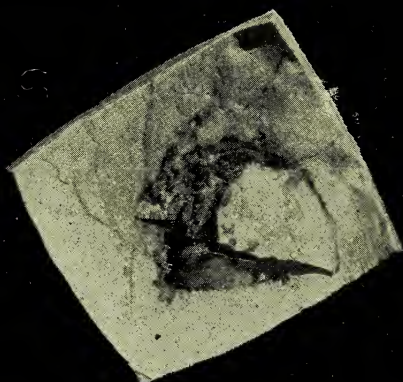


Fig. 3.



1. Linear fracture of vault of skull. 2. Depressed fracture of vault (from within). 3. Depressed fracture of vault (from without).

1. FRACTURE OF THE VAULT.

This may be a mere fissure, like a crack in a china plate (Pl. XIII, Fig. 1). The fissure may not be limited to one bone, but may cross a suture and extend quite widely. When compound, such a fracture may catch dirt or even a single hair, which, unless it is removed and the part disinfected, may become a source of serious or even fatal infection. Instead of a fissure the bones may be broken into several pieces, a comminuted fracture, either with or without depression of the fragments (Pl. XIII, Figs. 2 and 3). If depression takes place, there is usually a funnel-like hollow. There is no separation of the fragments, save what has been produced mechanically, for there are no muscles inserted on the skull to cause displacements similar to those which occur with most other fractures.

Symptoms.—If the fracture be a fissure, it can usually only be suspected, but may possibly be recognized in some cases by a “cracked-pot” sound. This may be elicited by percussion, best with, but sometimes even without, a stethoscope. It may be heard by the surgeon or by the bystanders, or may be perceived only by the patient himself. The same curious sound may be similarly elicited in hydrocephalus with beginning separation of the bones. If the fracture is much depressed, however, the depression, as a rule, may be easily felt by the finger. Care must be taken not to mistake for a fracture the circular effusion of blood which is so common after contusion. If there has been any destruction of the scalp, it is very possible to mistake an old depressed scar from this loss of tissue for an old depressed fracture of the skull. Occasionally there may be rupture of the dura even with simple fracture, and the cerebro-spinal fluid escaping under the scalp will cause a partially translucent, pulsating swelling, which becomes tense, especially with expiratory efforts such as sneezing, coughing, etc. It is a very rare but a positive sign of fracture. Still more rarely the fluid may come from the ventricles.

If the fracture be compound, its extent can be determined both by eye and by touch, but care must be taken not to mistake the ordinary sutures, and especially those of the Wormian bones or a slit in the pericranium, for linear fracture. The dark line of blood which marks a fissured fracture cannot be sponged or washed away, while the coagulated blood in an unbroken suture can be readily removed. This is a valuable means of differential diagnosis. The tooth-like character of the sutures is also a valuable aid. If cerebro-spinal fluid or brain tissue escape, the evidence of course will be positive.

Fracture of the inner table alone, which is very rare, can also only be suspected, but if there have been marked violence followed by symptoms of intracranial irritation or inflammation, the possibility that such an injury has occurred is increased; and if the symptoms be of localizing value—for instance, if there be a palsy of speech or of the right arm, or both of these symptoms, and if the blow have been received above and in front of the left ear—the possibility will become strong enough to warrant immediate operative interference.

The **prognosis** depends almost entirely on the amount of injury done to the brain rather than to the bone. As to the fracture itself, repair will take place, and the amount of callus thrown out in the skull is, fortunately, but little. Were it great, pressure on the brain would be the rule even in simple fissured fractures. If the fracture be compound, with loss of any fragments of bone, the loss will not usually be made good by new bone, but by fibrous tissue.

Treatment.—The conservative treatment of the last seventy-five years, which inculcated rest, antiphlogistics, sedatives, cold, and watching and waiting until the patient recovered or died, is curiously preceded and followed by a bold and active interference. Even pre-historic trephining, which was largely prac-

tised as a religious rite, must have been comparatively harmless, judging from the large number of skulls discovered with trephine openings healed before death. Prior to the earlier part of the nineteenth century the trephine was very frequently used: it is said that Chadborn trephined Philip of Nassau for epilepsy twenty-seven times, and instances of even a far larger number of operations on a single individual are known. The use of the trephine, however, was gradually abandoned, and for the last three-quarters of a century, almost disappeared until modern methods made the operative surgery of the brain so much safer that a return to frequent trephining and other similar operative interference has been a very notable fact within the last few years. Especially is this true since Macewen and Horsley have established the proper technique of such operations. At present, therefore, trephining with a view to the relief of immediate symptoms, and also quite as much for the prevention of later ill effects, is not only justifiable, but in many cases is demanded.

There are two forms of danger from such fractures: (1) the immediate dangers, which are first the injury to the brain, and secondly septic inflammation; and (2) the later dangers of severe continuous headache or of epilepsy and insanity, which are worse than death. For instance, even in a case of simple fracture there may have been a rupture of the dura and more or less laceration of the brain tissue, with effusion of a large or a small clot. If the clot be small, it will be absorbed before long, and healing of both the brain and the dura will take place by the ordinary cicatricial tissue of a lacerated wound. The skull, if it have been depressed, may even recover its vaulted contour (especially in children), but the scars which remain in the brain and dura are sometimes remotely the cause of epilepsy, insanity, and other complications of like character. Such a fracture, especially if compound and the result of a localized violence, may be attended with a clot, producing all the symptoms of compression of the brain. This clot and the brain tissue more or less intermingled with it may gradually be absorbed, but the brain is sometimes left permanently depressed, with spongy connective tissue, the meshes of which are filled with cerebro-spinal fluid; this sort of multiple cyst may keep up the palsy originally produced by the clot, and epilepsy, insanity, and other serious consequences may follow even if the patient recovers. The journals of the last few years have recorded a number of such cases, and the lesson to be derived from them is a most important and practical one. The doubt often expressed as to the wisdom of converting a closed fracture into an open one by an incision into the scalp has little weight, provided the surgeon observes the modern antiseptic precautions, without which methods no surgeon should touch a fracture of the skull.

Moreover, it is important to observe the great difference that should attend the treatment in cases in which a simple fracture occupies a limited area as a result of a localized violence—*e. g.* a blow from a hammer, and one in which the “bursting” force of a diffused injury produces long fissures in the bone and widespread injury to the brain. In the former such an exploratory incision may be entirely proper, in the latter in most instances it would be inadvisable.

If the fracture of the vault be simple, without depression and without cerebral symptoms, or if moderate cerebral symptoms have been present, but are abating, or if a fracture be only suspected, the case should be treated expectantly, but if any serious symptoms of intracranial mischief arise trephining should be done. *In simple fracture with marked depression* immediate preventive trephining should be done, even if there be no signs of encephalic mischief. Any violence sufficient to break a bone and depress it, there is good

reason to believe, may have lacerated the brain substance and probably the dura, and may be followed either by speedy inflammation or later in many cases by epilepsy, etc. if the depression remain. It is, however, but just to add that many surgeons still reject trephining until some symptoms of a lesion of the brain have manifested themselves.

In all *compound fractures of the skull* it is far better to shave the entire scalp rather than a small area, as is so often done. The removal of the hair even from a moderate area becomes very conspicuous, and it is better, even from an esthetic point of view, that the entire head should be shaved, so that the new crop of hair shall be of a uniform length all over the head. More than this, it is impossible to observe rigid asepsis without wide shaving, which thus becomes obligatory, even in women.

Compound fractures should always be explored by a large incision in the scalp. If the fracture be a mere linear fissure, it must be most carefully disinfected, and if it be impregnated with dirt or even if a single hair be caught in it, the outer table must be carefully chiselled away, turning the fissure into a V-shaped groove. The reason for this is that the danger lies far more in the probable infection than in the mere fissured fracture. If much depression exist even without symptoms showing that serious injury to the brain has been done, trephining should be done at once. It is still more strongly indicated if there be localizing symptoms which point to an injury of any of the cortical centers within easy reach, whether the fracture be simple or compound.

Punctured wounds of the brain are of course always compound fractures of the most fatal kind. In these the rule has long been absolute to trephine whether there be any brain symptoms or not.

If the surgeon sees that symptoms of intracranial mischief, such as local paralysis, epileptic seizures, beginning choked disks, etc., arise in any case of fracture of the skull, even after a considerable interval, his proper course is immediate operation. The longer the operation is delayed, the longer the "epileptic habit" has had a chance to form and the organic changes in the brain to become fixed, the less the probability of benefit from any operation. If, however, as in a case reported by Horsley, an old depressed compound comminuted fracture with laceration of the brain tissue, which caused in the first thirteen days of the patient's stay in hospital 2870 fits, could be cured by the removal of the scar tissue, we should not be deterred from attempting to relieve even the apparently most hopeless cases.

To sum up the matter, in any fracture of the vault, simple or compound, in which there are symptoms of intracranial mischief it is proper to incise the scalp and trephine. If there are no symptoms pointing to intracranial mischief, but there is marked localized depression from which we should infer the probability of either immediate or remote ill consequences, we should trephine. In all cases of punctured fracture the rule is absolute to trephine, open the dura, and disinfect. If, however, in a simple fracture there be no decided depression and no brain symptoms, the expectant plan may be pursued; but if the fracture be compound, it must be carefully disinfected, as has been described.

In giving these directions to operate it is of course understood that not only is the bone to be trephined, but if there is any reason whatever the dura must be incised and the brain inspected. Any further steps must depend on what is found. In 81 cases of compound fracture of the skull treated, as above described, by primary trephining the mortality was 1.23 per cent., while in 12 cases treated secondarily the mortality was 33.5 per cent. (Wagner). That is to say, later trephining, which should have been done at the time of the acci-

dent, caused an initial mortality nearly thirty times as great as simple primary trephining, to say nothing of later dangers.

2. FRACTURES OF THE BASE.

As has been already stated, fractures of the base (Pl. XIV, Fig. 1) either result from the extension of fractures of the vault to the base, or arise from indirect violence received through the spinal column or rarely through the lower jaw.

In addition to these cases a punctured fracture of the base may take place through three cavities at the base of the skull, the orbit, the nose, and the mouth. It is not very uncommon to see fractures of the base, with wound of the brain, caused by umbrellas, canes, knives, small sticks of wood, etc., which enter the orbit above the eyeball or gain access through the nose by piercing the cribriform plate of the ethmoid, while gunshot fractures are often the result of attempts at suicide by discharging a pistol into the mouth.

The fracture of the base may exist either in the anterior, middle, or posterior fossa of the base of the skull, the middle fossa suffering most frequently. Often more than one fossa is involved. Fracture of the posterior fossa has double the fatality of fracture of the other two.

The **symptoms** of fracture of the base are usually inferential, depending on the violence of the blow, and not uncommonly on our ability to detect extensive fracture of the vault probably extending to the base. In fractures through the orbit or other of the cavities just mentioned the evidence may be very clear, but, on the other hand, it may be very difficult to arrive at a positive conclusion. Not a few cases have occurred in which a thrust into the nose has produced severe bleeding, but in which the evidence of puncture of the base of the skull and injury to the brain has been very doubtful. This is equally true of the orbit, where a slight wound may be hidden in the folds of the upper lid. Large splinters of wood which have entered the cranial cavity either through the orbit or through the nose have been discovered at post-mortem examinations, their presence having been unsuspected during life. Of course the escape of brain substance through the ear, mouth, nose, or orbit is positive evidence. In fracture through the nose and mouth there may be vomiting of blood which has been swallowed.

The commonest sign of fracture of the base, especially in the middle fossa, is the escape of blood or cerebro-spinal fluid from the ear. Sometimes there will be bleeding from the ear, followed by the ordinary serous discharge from a wound, which may exist without any fracture of the base, but this bleeding will usually continue for only a short time. Long-continued bleeding, or, still more, the continuous discharge of a watery fluid, from the ear, if abundant, and especially if it is affected by the position of the head and is increased by any violent expiratory effort, such as sneezing, coughing, blowing the nose, etc., is almost positive evidence of such fracture, and especially if the watery fluid possess the chemical characteristics described below (p. 505). The patient may be directed to make these expiratory efforts with a view to testing the result. But in order that there shall be the escape of blood or cerebro-spinal fluid from the ear externally, the drumhead itself must also have been ruptured. The fact, therefore, must not be overlooked that there may exist fracture of the base without the escape of blood or cerebro-spinal fluid, on account of non-rupture of the drumhead. These fractures, however, are still compound, because they communicate with the external air through the Eustachian tube and the naso-pharynx, and their danger is all the greater



Fig. 1.



Fig. 2.

because of their insidious character. Another evidence of fracture of the base is paralysis of the cranial nerves, especially of the optic, facial, and auditory nerves. Deafness and facial palsy, therefore, are very significant of fracture of the petrous bone, and if either or both of them accompany discharge of fluid from the ear and other evidences of fracture of the base, the diagnosis is assured. Optic neuritis also sometimes occurs, especially in fracture of the posterior fossa (Battle). Its advent is usually not till toward the end of the first week, and may be delayed even till three or four weeks have passed.

When the orbital plate of the frontal bone has been fractured, even without puncture, there is another symptom of considerable value—namely, after a day or two blood will appear first under the conjunctiva of the ball of the eye, and later in the lids. In fracture of the posterior fossa, which is especially fraught with danger, the mastoid region should be examined for ecchymosis. This is easily overlooked, as its existence is often hidden by the ear, the pillow, and the hair. As shown by Battle, it appears first anterior to the tip of the mastoid process, usually some time after the reception of the injury, and spreads chiefly upward and backward with a crescentic border. The reason for these peculiarities is that the blood cannot reach the skin below the occiput on account of the dense cervical fascia, but follows the muscular planes sidewise, first reaching the surface anterior to the tip of the mastoid by the loose tissue around the posterior auricular artery.

The temperature during the shock following the injury is subnormal. This is succeeded by a rise to 100° or 101° F., followed often by a second fall somewhat below the normal. It will then remain subnormal or rise to the normal. If the temperature rises to any notable degree, we may suspect supuration and meningitis. If soon after the initial fall it rises quickly to 102° or in some cases 106° , 108° , or even 110° , we may be sure there has been some serious laceration of the brain, with almost certainly a fatal issue.

The **prognosis** in fracture of the base had always been an unfavorable one until of late years. The danger of infection was especially great, because the points through which septic infection may penetrate are hidden, and therefore were generally overlooked. These sources of infection are chiefly, as has been pointed out, the ear, mouth, nose, and orbit (if punctured); all of them are more or less inaccessible, difficult to disinfect, and likely to be overlooked. But the last few years have seen immense improvement in our methods of treating such fractures. The urgent necessity for disinfection of these dangerous cavities has been recognized, and as a result fractures of the base are much more amenable to treatment and their danger has been greatly reduced. A sudden, and especially a high, rise of temperature, as has just been stated, is a most unfavorable symptom.

Treatment.—In case of fracture of the base the fluid which escapes from the ear, nose, etc. ought to be collected, and examined to determine whether it be cerebro-spinal fluid. If it be, it will contain a small amount of albumin and a large amount of chlorides, and will sometimes give the reaction for sugar with Fehling's test. Next the cavity or cavities involved must be carefully disinfected. The ear should first be mechanically cleansed of wax, dirt, blood-clot, etc., and then should be most carefully disinfected by a stream of warm sublimate solution, 1 : 2000, or hydrogen peroxide, till it is absolutely clean. It may then be filled with sublimated cotton, iodoform gauze, or some similar disinfectant, and a sublimate dressing be applied externally. In the orbit the same rule must be carried out, and if the fracture be a punctured one, carrying infection into the brain, the wound must be enlarged and thoroughly disinfected; as a rule it is best to trephine or remove by the gouge and chisel

sufficient of the roof of the orbit to inspect the dura and brain itself if need be, and then after having disinfected the parts to drain them.

In the nose and mouth this proceeding must be modified, inasmuch as corrosive-sublimate solution would be dangerous from the possibility of its being swallowed. The parts, however, should be thoroughly washed with water as hot as can be borne, and then with a boric acid solution, which in the mouth must be frequently repeated by gargling, and in the nose by Thudichum's douche or by spraying. The nose should then be lightly packed with sublimate gauze or sublimate cotton, which will not only sterilize the air that may enter by the anterior nares, but also, by obstructing the passage of the air through the nose, tend to prevent infection by the posterior nares. Iodoform or boric acid may be insufflated into the naso-pharynx, and thus reach the orifice of the Eustachian tube. Of course it is recognized that the nose and mouth cannot be made absolutely aseptic, but only approximately so. But even this partial asepsis has resulted most hopefully in treatment. In rare cases drainage-tubes may be inserted into the cranial cavity through the nostrils, if need be by puncture of the cribriform plate. Similarly, for draining the middle fossa the skull may be trephined above and behind the auditory meatus. Thoroughness of disinfection and of drainage must be an absolute rule. To attain these ends the operative interference may have to be considerable, but they must be attained at whatever cost. If a fracture of the base is extensive, the head may be shaved and a plaster cap applied so as to immobilize the fragments. Of course the utmost quiet both physical and mental is necessary, with restricted diet, attention to bladder and bowels, and treatment by drugs to combat the symptoms as they arise.

IX. WOUNDS OF THE BRAIN.

These are produced by severe falls, by kicks, by the penetration of knives, nails, swords, bayonets, rifle-balls, etc., and may be received either on the vault or sides of the cranium or through the orbit, nose, or mouth. With the exception of such wounds in children through the open fontanelles, or possibly in adults through a large parietal foramen, they are necessarily accompanied by fracture of the skull. In many cases they are punctured fractures of the most dangerous kind. They must all be more or less septic in character, with laceration of the brain substance by the vulnerer instrument, with not uncommonly fragments of bone, hair, cap, etc. carried into the brain, and they are always attended by more or less severe hemorrhage. Recovery after a severe wound of the brain sometimes follows almost miraculously; as, for instance, in a recent case where a would-be suicide deliberately drove four nails through the skull into the brain, one being driven through the occipital bone. Knife wounds have been repeatedly recovered from, the blade of the knife having remained in the brain for many days or even years. Not uncommonly pistol-balls have remained in the brain for years before producing any serious symptoms, and sometimes the foreign body has been discovered only at the post-mortem, no symptoms whatever having arisen. The celebrated Vermont "tamping-iron case," in which a patient recovered after being wounded by a tamping-iron which passed entirely through the brain from below upward, is too well known to require repetition in detail. Loss of brain substance is by no means invariably fatal, although of course always serious.

The **symptoms** in such cases are occasionally surprisingly slight and long delayed, but more commonly are immediate and severe and in proportion to the extent of the injury received. Usually, even if the injury be moderate, head-

ache soon sets in, with all the symptoms of a developed encephalitis, followed, if not soon relieved, by coma and death. Very often there may be localizing symptoms of the greatest value which will enable us to discover an otherwise hidden injury. For instance, if a knife-blade have penetrated the speech center above and in front of the left ear, and have been broken off and hidden by the scalp and hair, the motor aphasia which follows will guide us to the region where we should search for the injury. If word-blindness or apraxia occur, the injury will be more apt to be above and behind the ear; if there be hemianopsia, the region of the cuneus should be examined; while palsy of the face, arm, or leg will point to their respective cortical centers as the probable site of the injury. In all such cases the entire head should be shaved, in order that the surface of the scalp may be examined with minute care. The vulnerating body also, if possible, should be examined, to see whether any part has been broken off and possibly left in the brain, and the evidence of eye-witnesses to the accident is always to be carefully weighed. In all cases which may involve a trial at court or a coroner's inquest careful notes should be made at the time. The question of foreign bodies in the brain will be treated presently.

Treatment.—The head should be shaved, and then with the greatest care the parts should be made as aseptic as possible, and all foreign bodies on the outside should be washed away or removed with forceps. Foreign bodies, fragments of bone, etc. which have been driven into the brain should all be removed and the depressed bone elevated; the cavity in the brain should also be disinfected. Hemorrhage should be arrested by ligature, by hot water, or by pressure. The dura, if not lacerated beyond repair, should be sutured, and possibly its place may be supplied by a bit of the pericranium. Drainage should be provided, best by rubber tubing, and then the flap of scalp should be replaced and sutured, and an ample sublimate dressing applied. The after-treatment before indicated should be carried out. Secondary abscess will be very apt to follow in many cases, and should be watched for, and the pus evacuated as soon as possible.

X. GUNSHOT WOUNDS OF THE HEAD.

These are frequently more serious than they appear to be at first. A glancing rifle-ball, and still more a larger shot, impinges with such force that while only the scalp may seem to have been injured, in reality the bone may have received sufficient injury to produce necrosis, and even the brain and its membranes may be or may become involved. The outer table may be only fissured, or, if it apparently have escaped, a fragment of the inner table may have been broken off. The scalp not uncommonly sloughs to a considerable extent. In other cases the most frightful and extensive injuries of the brain and the skull may be produced, as is shown on Plate XIV (Fig. 2).

Gunshot wounds directly involving the brain may be either perforating or penetrating. A penetrating wound is one in which the missile enters and does not emerge, and a perforating wound is one in which it passes entirely through the head. The injury to the skull or brain may vary from a comparatively slight wound to one which inflicts immense and widespread injury both to the skull and to its contents. The difference between the wound of entrance and the wound of exit is apt to be far more marked in the skull than in the soft parts. At the wound of entrance the aperture in the external table may be no larger than the ball itself, or may even have been reduced to a simple slit, whereas the inner table may be quite extensively fractured. At the wound of exit the reverse is true. The outer table will be more extensively

fractured than the inner, and in addition the entire aperture at the wound of exit, as the ball strikes on the concave surface of the skull, is apt to be much larger than the wound of entrance (Fig. 210).

FIG. 210.



Perforating Gunshot Wound of the Brain, involving the cuneus and producing hemianopsia. The wound of entrance is marked by a small linear scar below and to the right of the wound of exit, which produced the large excavated scar (Thomson and Keen).

The **symptoms** are very much the same as those in any other wound of the brain, with the exception that, owing to the widespread injury, there is less probability of limited localizing symptoms, though these may exist.

Treatment.—The recent advance in cerebral surgery again has materially changed our treatment of such wounds. The difference between the modern treatment of gunshot wounds of the brain and the older methods is due to the application of antiseptic methods and the consequent boldness with which we interfere, to the use of the aluminium gravity probe, and to our knowledge of the facts that drainage of the brain is not only feasible but essential, and that for the purpose both of searching for the bullet and of removing it we should often make a counter-opening by the trephine. The details of the treatment may be stated briefly as follows: (1) Shave and disinfect the entire scalp. (2) Disinfect the

entire track of the wound from the wound of entrance to the wound of exit, if one be present, or to the certain or probable site of the ball if there be no wound of exit. (3) If there be any serious hemorrhage, the wound of entrance or the wound of exit or both must be freely enlarged by the rongeur forceps or the trephine, and the vessels secured by ligature, or occasionally the hemorrhage may be arrested by pressure or by hemostatic forceps. (4) The bullet or other missile must be removed if possible. For this purpose, if necessary, a counter-trephine opening must be made. (5) Free drainage must be secured, again if need be by a counter-opening. For this purpose the drainage-tube may have to traverse the entire brain. (6) Apply antiseptic dressings, and continue the subsequent treatment on the principles already laid down. Most of the points above enunciated have already been considered, but some require a few words.

The *removal of the ball* has always been one of the principal difficulties in gunshot wounds. Fluhner has introduced a probe of great value (Fig. 211), made

FIG. 211.



Fluhner's Aluminium Gravity Probe (natural size, except the length, which is 12 inches).

of aluminium, with large conical ends of different sizes. The material is so light that if the head be so placed that the track of the ball is vertical, the probe if allowed to enter by its own weight will not produce a false passage, but will follow the track of the ball. If the ball is near the wound of entrance, it may be extracted through this wound, but if it has penetrated so far as to be more accessible from the opposite side of the skull, a counter-opening should be made at the point at which the probe would emerge if it

were carried through the head. It is important, therefore, in using the probe to measure its length, and when the probe has reached the ball to measure the protruding portion, which will give us the depth at which the ball lies from the wound of entrance. Then, pushing the probe farther on just to the counter-

FIG. 212.

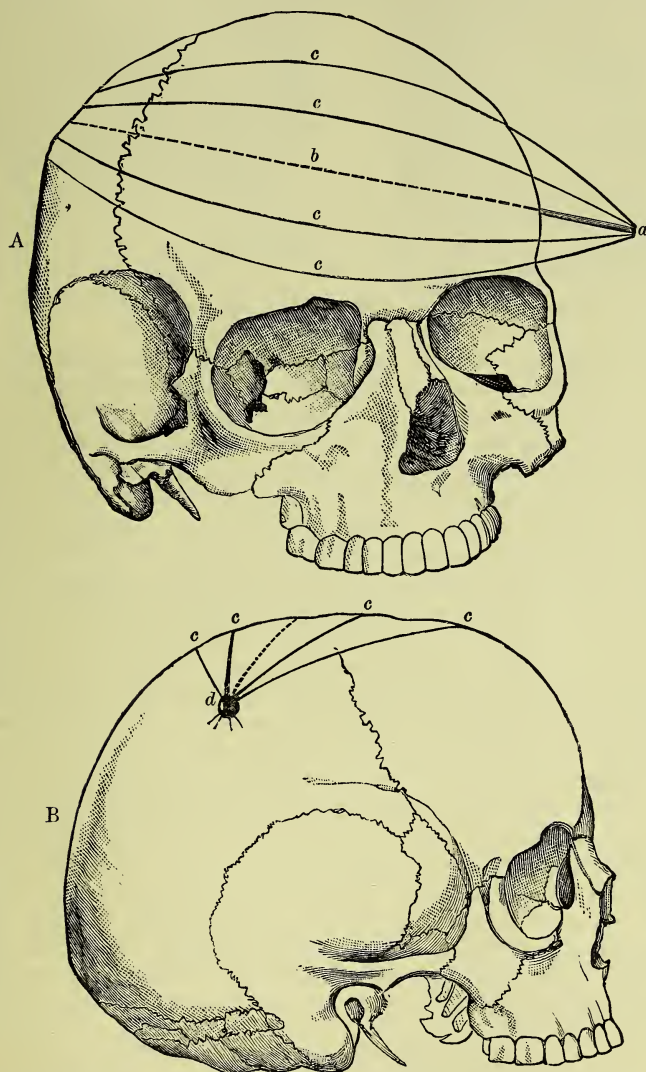


FIG. 212, A, B.—Method of Determining the Point for Counter-trephining: *a*, the protruding end of the probe; *b*, its axis continued to the counter-point *d*; *c*, similar lines all converging to *d*, the place for the counter-opening. These lines are fixed by regarding the skull in various planes: first from above, then in front, etc., and following the line of the protruding part of the probe to the opposite side of the skull (Bryant).

opening, and again measuring the part which protrudes from the wound of entrance, we ascertain the depth at which the ball lies from the counter-opening. Two strands of antiseptic silk are now attached to the extremities of the probe and are drawn through the wound by the withdrawal of the probe. To one of these strands a No. 9 (French) gum catheter is attached. This must be new and well disinfected, especially in the interior, and made rigid by a disin-

fectured straight stylet. A pair of forceps is now tethered to the catheter by a loop of silk around one of its arms, and the ball is searched for at its known depth, first above, then below, to the right and to the left of the catheter guide. The forceps should not be swept around the catheter, but should be withdrawn and reintroduced for each search. The object of this is, of course, to avoid unnecessary injury of brain substance. The ball, if found, having been removed, the second strand of silk is utilized to draw a drainage-tube directly through the wound. In Fluhner's remarkable case the ball entered the forehead, struck the occiput, and rebounded in a track determined first by the natural angle of reflection and secondly by the influence of gravity. He made a counter-opening, and found the wound made in the meninges by the ball on striking the inner surface of the occiput, and from this as a new point of departure made another search in the manner above indicated, with the result not only of removing the ball, but also of saving his patient.

Dr. Girdner has devised a very ingenious instrument which may aid in locating the ball, viz. the "telephone probe." One end of the probe is attached to a telephone receiver which is held to the ear. The other cord attached to the telephone receiver has a metal handle which is moistened and placed in the patient's closed hand or against some other part of his bare skin. If the probe touches the ball, a grating sound peculiar to the contact of the probe with a metallic substance is heard through the telephone receiver. Formerly balls lodged in the brain were allowed to remain unless they were quite superficial and readily found. The idea was that any meddling with the brain with a view to the removal of foreign bodies was unwarranted. Modern brain surgery has changed all this. Antiseptic disturbance of the brain, though of course to be deprecated unless essential, we now know is not so dangerous as the retention of the foreign body. Wharton has shown by an analysis of 316 cases of foreign bodies lodged in the brain, occurring even in the pre-antiseptic days, that in 106 in which removal was effected 34 (32 per cent.) were fatal; whereas in 210 cases in which the missile was not removed 122 (58.1 per cent.) died, and of those who recovered 10 succumbed ultimately from the effects of the retention of the missile, and many others suffered from epilepsy and other physical and mental troubles. Bradford and Smith have analyzed 89 recent cases of similar wounds of the brain, with a mortality of 33.3 per cent. following removal of the ball, and 54 per cent. when the ball was not removed. If the bullet cannot be found by the wound of entrance without undue interference with the brain, thorough disinfection of the wound should be made, followed by drainage by a rubber tube reaching the entire depth of the wound. If a counter-opening have been made, disinfection and through-and-through drainage should be employed. The head should then be placed so as to favor drainage, the wound covered with antiseptic dressings, and the after-treatment carried out as before.

XI.—FOREIGN BODIES IN THE BRAIN.

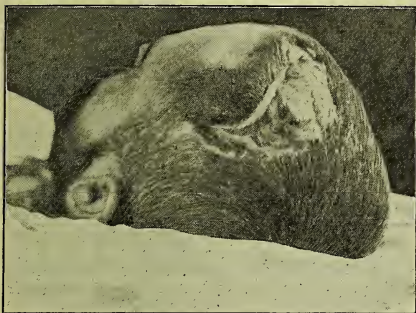
The treatment of foreign bodies in the brain has already been practically considered under the head of Compound Fracture and especially under that of Wounds and Gunshot Wounds, and the reader is referred to these subjects.

XII.—FUNGUS CEREBRI, OR HERNIA CEREBRI.

The former is the better term, as there is not commonly a true hernia of the brain. It is usually a growth from connective tissue (the neuroglia), and rarely contains much true brain substance (Fig. 213). Fungus cerebri, of course, cannot take place unless the dura has been opened, and in fact even in

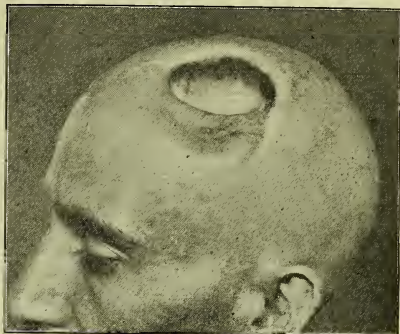
this case it is not likely to occur unless the brain substance itself has been wounded. Septic wounds by their failure to close early involve far greater

FIG. 213.



Removal of a Large Fibroma from the Brain (original): fungus cerebri soon after operation.

FIG. 214.



Depression in the Head, seven years after operation (Fig. 213).

danger of fungus cerebri than the aseptic wounds of modern surgery, which close by immediate union, because the neuroglia is softened and the intracranial pressure is markedly increased. Hence trephining if done with modern precautions involves but little danger of such a growth. Even if the dura has been opened, if it be closed either by interrupted or by continuous sutures there will be scarcely any risk, but the moment that any brain substance is removed the general risk of the operation, and the especial risk of fungus cerebri, are very much increased. If, therefore, in any operation it is necessary to remove any of the dura, and still more if any of the brain substance is removed, the suggestion made by Keen may be carried out, that a piece of the pericranium should be entirely detached from the under surface of the flap of scalp, turned upside down so that the osteogenetic surface shall be uppermost, and secured to the dura by a few interrupted sutures. Such a piece of the pericranium will retain its vitality and close the opening which otherwise would exist in the dura, and thus prevent a fungus cerebri. A fungus cerebri is usually more or less rounded and its surface lobulated, of a grayish dirty-white appearance, and soft to the touch; it produces no pain, and may pulsate with the heart. It is often the site of moderate or considerable discharge, and there may be escape of cerebro-spinal fluid even from the interior of the ventricles. It is apt also to bleed. The intelligence of the patient frequently remains good. The diagnosis, of course, is easy.

Treatment.—As a rule, the best treatment is to let the fungus alone or to dress it once or twice daily with simple antiseptic dressings. If it heals slowly, skin-grafting may be resorted to. Pressure by sponges or by dressing, though sometimes useful, is often followed by symptoms of intracranial pressure or by convulsions, and then has to be abandoned. If cut off by the knife or destroyed by the cautery, it almost always sprouts anew. It is a curious fact that as soon as such a fungus has cicatrized there is a sudden subsidence, so that instead of a bulging mass of tissue there is a marked depression, which is always permanent, and may be even one and a half inches deep. (See Figs. 210 and 214.) The latter shows the result seven years after removal of a large brain-tumor followed by the fungus cerebri shown in Fig. 213. An important lesson can be taught by such a depression in the brain. If the patient lies down, or even bends over, the hollow is immediately effaced. So too in violent expiratory efforts, such as sneezing and coughing,

the same effect will be produced. Such a case shows very clearly the rapid changes effected in the intracranial circulation and the cerebro-spinal fluid either by position or by violent expiratory efforts. This explains why when suffering from headache we walk on tiptoe in order to avoid any shock to the brain, and also why it is unwise to do any operation for cataract or other operation involving an incision into the ball of the eye when there exists cough from bronchitis or other similar cause.

XIII.—INFLAMMATION OF THE BRAIN AND MEMBRANES FROM TRAUMATISM.

Various terms are used to indicate inflammation of different parts of the brain and its membranes. The terms *encephalitis* and *cerebritis* are used indifferently for inflammation of the cerebrum, and *cerebellitis* is occasionally used for inflammation limited to the cerebellum. *Meningitis* means inflammation of the meninges of the brain, and *arachnitis* inflammation of the arachnoid itself. Two forms of meningitis also may be distinguished pathologically: *pachymeningitis*, or inflammation of the hard membrane or dura, and *leptomeningitis*, or inflammation of the arachnoid and pia considered as one. The differential diagnosis between these two forms can be made only on the post-mortem table; clinically they cannot be distinguished. Moreover, inflammation of the brain, of the pia and arachnoid, or of the dura is sure sooner or later to extend to either or both of the others, and the consequence in any form may be the production of suppuration, abscess, effusion into the ventricles, and softening of the cerebral tissue if the brain itself is involved.

Causes.—These are usually traumatic, such as contusions or lacerations of the brain, fracture of the skull, etc. Caries and necrosis of the bones of the skull, and occasionally pyemia, may also be the starting-point of such inflammation. Caries and necrosis of small portions of the skull not infrequently may cause a localized and limited meningitis, which is far less dangerous than the diffused form resulting from contusions or similar traumatisms which shake the brain as a whole and are followed by the most intense forms of diffused inflammation. Very often a piece of necrosed bone will lose its vitality, either from localized injury or from syphilis, and its removal will disclose a layer of granulation-tissue under it extending somewhat beyond the layer of necrotic bone; yet in this case the rest of the membranes and the brain itself may entirely escape.

Meningitis and encephalitis are either chronic or acute, and it is necessary to distinguish the two forms. Encephalitis will be used as a type of all these forms of inflammation.

1. Acute Encephalitis.—Symptoms.—These usually arise within a day or two after the injury, and with distinct symptoms, such as pain in the head, which is apt to be general, photophobia, intolerance of noise, and rapidly rising fever until the temperature is 103° or 104° , with flushed face, full, bounding pulse, contracted pupils, and a rise of surface temperature at the site of the injury. The bowels will be constipated and the patient sleepless and restless. Delirium is apt to set in early, with twitching and strabismus, followed by drowsiness which deepens into coma, and as the symptoms deepen there will be paralysis with involuntary evacuation of urine and feces, and the patient will die in a typhoid state. The ophthalmoscope will rarely show choked disk. At the post-mortem the dura will be found inflamed and reddened, the arachnoid usually whitish and opalescent, and if the inflammation have progressed far enough the hemispheres will be covered with a greenish-yellow layer of pus. The brain substance itself will be softened and vascular,

and very likely a layer of pus will lie at the base of the brain. The ventricles will be filled with turbid serum.

It is very important to distinguish between such inflammation of the brain and uremic coma. In uremia the fundus of the eye will probably show patches of albuminuric retinitis, while the urine will contain albumin and tube-casts, and there will be very likely coexisting œdema, especially about the ankles and the face. Not uncommonly also there may be chills at the beginning of the suppurative process in encephalitis, which are generally absent in uremia.

Treatment.—The patient should be placed in a quiet, dark room, with the head raised and the entire scalp shaved. The bowels should be quickly purged, but not immoderately, lest the patient be weakened by it as well as by the physical efforts necessitated by such purgation. The bladder should be carefully looked after, and retention of urine relieved by the catheter. Cold should be applied to the head, either by an ice-bag or by a coil of tubing for cold water. Occasionally, but not often, bleeding from the arm may be of value, but if so it will be only in the robust and at the beginning of the attack. Leeching or wet cups applied to the mastoid region and nape of the neck are better, as they directly withdraw venous blood from the lateral sinus through depletion of the radicles of the mastoid veins. Large doses of bromide, up to 100 grains, or even more, per diem, aconite, calomel guarded by opium up to the point of beginning ptialism, and hypnotics, such as hydrobromate of hyoscyne, chloral, paraldehyde, etc., should be given to procure sleep. In the early stages alcohol in any form is to be avoided, as an additional excitant, but in the later stages, when exhaustion and especially the typhoid state develop, it may be of value. In the stage of exudation, when pressure symptoms begin, blisters to the nape of the neck and occasionally to the scalp, with mercury and iodide of potassium, are the best remedies, if any remedies can be said to be best in a disease which is so often hopeless from the start. Should the patient recover, as he occasionally will, the most careful after-treatment is essential. Convalescence must be conducted very watchfully as to diet, exercise, and occupation. No physical exertion, even of the mildest character, should be allowed until the convalescence is well established. Absolutely no mental effort should be allowed, especially that involving any excitement, worry, or over-study, for many weeks, or, better still, months, after the attack.

2. Chronic Encephalitis.—The causes of chronic encephalitis are the same as those of acute, but usually the initial traumatism is less severe and the inflammation follows after a longer interval, but it is always much more apt to result in the formation of pus, either extradural, subdural, or cerebral. Distinct accumulations of pus will be considered under the head of Abscess.

Symptoms.—The patient has received probably a blow on the head, followed by the lighter symptoms already described under Contusion. From these he will recover more or less rapidly, and will apparently be again a well man; but days, weeks, or even months, after the injury he will begin to suffer with vague symptoms of cerebral trouble, especially headache, which very frequently will be localized at or about the site of the injury. He will be unable to attend to business or study for any length of time. There will be more or less mental dulness and irritability of temper. Without any change in his acuteness of vision, if the eyes are examined choked disk will be found. Not long afterward there will very likely be a chill, followed by a localized paresis or paralysis, and if the case terminate fatally the drowsiness will deepen into coma, and he will die with the same symptoms as those of acute encephalitis.

Treatment.—The same care should be given to the patient as before in the matter of mental quietude, physical rest, diet, moderate purgation, and watching the bladder if necessary. Blisters to the back of the neck and cold to the head are useful. Internally calomel and opium in the earlier stages, and mercury and iodide of potassium in the later, will be found most useful. Care must be taken not to confound the dulness caused by the opium with the coma which may arise in the course of the disease, and, conversely, the coma must not be mistaken for opium narcosis. If the patient recover, the same watchful after-treatment that has been above described must be stringently carried out. No one has better described the need for such rest after any concussion or inflammation of the brain than Mr. Hilton, in Lecture III. of his book *Rest and Pain*.

3. **Operative Interference in Meningitis and Encephalitis.**—Very naturally, in view of the boldness of modern cerebral surgery, the question will arise whether operative interference will not give a better chance for relief than the treatment above indicated. As yet, it is too early to be dogmatic on this point, for there is little experience to guide us. But as inflammation in the brain as in other parts of the body is followed by exudation and suppuration, and this exudate or pus, not being able to escape, produces rapid tissue-changes and symptoms of pressure, and as the bony skull cannot be perforated by the serum or pus, and so allow it to escape and relieve the pressure, as is the case in the soft parts, it seems reasonable that we should interfere surgically and afford a means of escape for the exudate by trephining, opening the dura, and draining. All surgeons would be agreed upon the propriety of this treatment when there is localized suppuration, but there is still a difference of opinion as to its propriety in the early stages when the exudate is only serous. It is, however, possible that just as when exudation or suppuration occurs under the dense periosteum, we incise it and give exit to the fluid; and when increased intraocular pressure occurs, an incision relieves it and saves the eye; or in an orchitis an incision relieves the pain and saves the testicle; so in inflammation of the brain future experience may show that it will be wise to trephine for drainage of the effused fluids before they have gone on to the stage of suppuration or abscess and done irreparable damage to the brain. In that case we shall be able hereafter to cope with the dangers of cerebral inflammation far better than we have been in the past, and our mortality records will be immensely improved. Very little has been done in this direction, however, and hence these views are put forward tentatively.

Mr. Horsley has already urged this course of treatment, and very properly his opinion carries great weight. In cases of chronic encephalitis probably such operative interference will be more likely to be followed by success than in the acute form, for in chronic encephalitis the symptoms often indicate localized pressure on a single cortical center or on more than one neighboring center. In this case the indications would be clearly in favor of trephining, incising the dura, or, it may be, puncturing it, with a view to the relief of the pressure. Whether acute or chronic, those cases afford the greatest probabilities of cure in which there is evidence of localized rather than diffused, and especially of basilar, inflammation, and in which there is a local production of serum or of pus. One remarkable acute case has been reported by Mr. A. E. Barker, in which there is reason to believe that he evacuated an ounce of odorless pus from the fissure of Sylvius, with good result. While a single case like this does not establish a rule, it at least suggests a possibility which must be taken into account and acted upon, especially in so fatal a disorder. In any such operation we must be guided absolutely by our present knowledge of the localizing

symptoms, which have already been stated and which are becoming more and more exact. Even in general encephalitis it is perhaps not too much to hope that operative interference may find some means of relief, although of course it is far less apt to do so than where the symptoms indicate localized pressure.

If the inflammation arises from a general shaking and laceration of the brain, it is often basilar, and the obtaining of good results from trephining is more doubtful.

XIV.—ABSCESS OF THE BRAIN.

Causes.—Nearly 50 per cent. of the cases of abscess of the brain arise from suppuration in the ear, especially the middle ear. This will be considered in connection with other cerebral disturbances having the same origin. The next most frequent cause is injury, such as compound fracture, or, rarely, simple fracture if a splinter is broken off from the inner table and driven into the brain. Not uncommonly, however, it may arise from simple contusion, which may not even have been very severe, and from which recovery apparently may have taken place. Weeks or months after such an injury, and in some cases even a number of years after it, abscess of the brain has been developed. Thus Mr. Damer Harrison has reported the case of a boy fifteen years old who received a severe blow on the *left* side of his head at the age of four or five years. No serious symptoms followed, but at fourteen years of age a number of muscles in his right arm were the subjects of twitchings. Eight days before admission to hospital he had received a blow on the *right* side of his head from a pair of tongs. Three days after this last accident convulsions suddenly set in, beginning in the *right* arm and spreading to the face and leg on the same side, followed by complete right hemiplegia. Mr. Harrison trephined him, not at the site of the second injury, but at the cicatrix of the first injury, received ten or eleven years before, and evacuated four drams of fetid pus; the boy recovered. This may serve as the type of a number of similar instances of late results from such an injury.

Besides such aural and traumatic cases, cerebral abscess sometimes follows septic disease of the lungs or ulcerative endocarditis, and in pyemia multiple abscesses of the brain not uncommonly exist. Occasionally tubercular abscesses are found.

Pathological Anatomy.—The site of the abscess may be between the dura and the skull, *extradural abscess*; or between the dura and the brain, *subdural abscess*; or in the substance of the brain, *cerebral* or *cerebellar abscess*. Except extradural abscess, which will be considered later, there are no means of accurately distinguishing these various forms.

If the cause of the abscess is traumatic, it is generally situated under the site of the injury, to which we may usually be guided by the scar, although, as already stated, sometimes no such mark exists. Occasionally it will occur on the opposite side of the head, being caused by the laceration of the brain, as already explained, by *contre-coup*. Its site must always be determined much more by the localizing symptoms than by the scar or the history, as, for instance, in a case reported by Macewen, in which the abscess was in Broca's convolution—that is, the third or inferior frontal at its posterior end—and the cicatrix was on the forehead. The size of the abscess will vary, from a cavity containing a dram or two of pus up to one involving a large portion of the hemisphere. It is commonly single, except in tubercular cases, where it is frequently multiple, although single tubercular abscesses have been reported. If large, they sometimes rupture into the ventricles, invariably with a fatal result.

Symptoms.—These may be divided into three classes: (1) those due to the suppurative process; (2) those due to pressure; (3) the focal or localizing symptoms.

(1) *Symptoms due to the Suppurative Process.*—Usually a rise of temperature is significant of suppuration in other parts of the body, but it is especially noteworthy that in cerebral abscess the temperature, as a rule, is either normal or subnormal, even when the other symptoms indicate the gravest peril. Occasionally there will be an initial rise, followed by a fall to normal or below it, and then toward the end of the disease there will be another rise, often accompanied by delirium, and the temperature again subsides, only to rise after an interval if life is sufficiently prolonged. The local temperature over the abscess, it is stated, rises, even if the general body temperature be subnormal. If, therefore, in any case following a traumatism symptoms of serious intracranial pressure set in, with the body temperature normal or subnormal while the local temperature rises and the pulse is slow, the first thought of the surgeon should be that he has to deal probably with abscess of the brain. A chill not uncommonly occurs, but may be absent. Of course anorexia, vomiting, general malaise, etc. are present. Somerville has stated that when there is pus in the brain the urinary chlorides will be below normal and the phosphates will be above.

(2) *Symptoms due to Pressure.*—Headache is one of the most important, and is almost always present, and not infrequently of a severe character, so that the patient will moan constantly. Should the temperature rise the headache is often aggravated, and sometimes is located distinctly over the lesion, but very commonly it is first general and then focal. The pulse is always slow, and may even fall to 30 or 40. Respiration is often of the Cheyne-Stokes type. The mind soon becomes clouded, and the dulness gradually deepens into coma, and the bowels and bladder are evacuated involuntarily. Epileptoid convulsions often occur, but if the abscess arises from ear disease and is situated in the temporo-sphenoidal lobe, the patient may be free from them. Sensation is not usually impaired to any extent. Choked disk may be present or absent, and may be unilateral or bilateral. If bilateral, it is commonly more marked on the same side as the abscess, though occasionally this is reversed. Sometimes ptosis may be present, and occasionally the entire third nerve is paralyzed, while the sixth escapes, though this is sometimes reversed. The pupil on the side of the lesion is usually dilated and more or less immobile. The patient's general condition fluctuates remarkably as to these symptoms of pressure, giving us hope sometimes of spontaneous recovery, and then becoming worse than before.

If the abscess is *cerebellar*, the diagnosis is even more obscure. There may be occipital headache and muscular rigidity of the neck. If it be in the middle lobe, there will be muscular incoördination, and especially a drunken, unsteady gait. Vertigo and vomiting are frequent and persistent. There will sometimes be tenderness on pressure and pain on percussion over the cerebellum. Choked disk is commonly absent.

(3) *Focal or Localizing Symptoms.*—If the abscess is situated in the left temporo-sphenoidal lobe, it may press on Broca's convolution, and this will produce motor aphasia. If it involve or press upon the lower part of the Rolandic motor region, it will produce paresis or paralysis of the opposite side of the face, followed by paresis or paralysis of the arm, and finally of the leg as the pus creeps upward in the motor region. Sometimes there will be distinct squint, from paralysis of the sixth nerve. Should the abscess arise in the frontal lobe from contusion or fracture of this region or from nasal disease, localizing symp-

toms are apt to be absent, since the frontal lobe is a latent region; and the same statement applies to the occipital lobe unless the abscess involves the cuneus, when hemianopsia of the same half—that is, right or left—of each retina will follow. If the angular or supramarginal gyrus is involved, there may be monocular Argyll-Robertson pupil,¹ as pointed out by Oliver. The local temperature of the two sides of the head should be taken, though it must be interpreted with care; and it must be remembered that the left side is normally of a slightly higher temperature than the right. Pressure on the skull and percussion, like the local temperature, may be of value, but must not be relied upon absolutely. Ferrier states that pain which is not spontaneously complained of, but is elicited by percussion, is of greater value than mere tenderness on pressure. As a means of diagnosis between cerebral and cerebellar abscess this is of some value so long as the mental condition of the patient is sufficiently clear.

Differential Diagnosis.—1. *Meningitis*.—Meningitis and abscess are very often extremely difficult to differentiate, but we may be helped in the diagnosis by the fact that meningitis is apt to develop within the first three or four days, whereas an abscess does not usually form earlier than the end of the first week. In meningitis also there are apt to be early dulness, deepening into coma and actual delirium, photophobia, and contraction of the pupils, with high general temperature and marked rigidity of the cervical muscles.

2. *Mastoid Disease*, following suppurative disease of the middle ear, sometimes occasions serious cerebral disorder without abscess. Trephining the mastoid, which should generally be done at an early stage, will eliminate this as a factor in the problem. Mastoid disease will ordinarily be accompanied with swelling, cedema, and pain in the mastoid region. It must be remembered also that a cerebral abscess and mastoid disease often coexist.

3. *Extradural Abscess* may be distinguished from cerebral abscess by the symptoms given later.

4. *Thrombosis of the Lateral Sinus and Pyemia*.—Commonly the internal jugular vein, as well as the lateral sinus, will be invaded by the thrombus, and will be hard and cord-like, and the veins of the face are apt to be swollen. Pressure and percussion over the lateral sinus will be painful. The temperature will fluctuate violently, rising far above the normal, and there will be rigors, sweating, and general prostration, and eventually suppuration in the joints, with pyemic symptoms referable to the lungs and liver. Usually also the intellect is much clearer than in abscess, at least in the early stages.

5. *Tumor*.—A tumor is ordinarily slow in its growth, and often attended with distinct localizing symptoms at a comparatively early stage, while abscess usually pursues a much more rapid course. There are in abscess commonly the history and often the evidence of distinct injury or of disease of the ear or nose. Choked disk is almost always present in tumor, and is generally double and much more frequent than in abscess. Moreover, abscess is far more common in the temporo-sphenoidal lobe or in the cerebellum, especially from ear disease, while tumor is rare in these situations. In other parts of the brain, on the contrary, tumor is more common than abscess. The temperature is not apt to rise in tumor, but should there be any marked and rapid fluctuation, and especially any prolonged subnormal temperature, it would be strong evidence of abscess; if the patient is syphilitic, he is more apt to have tumor than abscess.

¹ The Argyll-Robertson pupil is one which is more or less contracted, but the iris does not contract when light is thrown upon the retina, although it varies with accommodation and convergence. If this peculiarity exists in one eye only, it is called monocular Argyll-Robertson pupil.

Treatment.—A few early attempts to evacuate an abscess of the brain, by Dupuytren, Detmold, and others, are on record, but it is only since cerebral localization has enabled us to diagnosticate with comparative accuracy the location of an abscess, and within the last few years, since cerebral surgery has advanced with such rapid strides, that surgeons have been emboldened to interfere in an operative way in cases of such abscess, and in very many instances with the happiest results. When the abscess is located, the head should be shaved and disinfected, as already described. If the localizing symptoms point to the region of the scar, we should trephine at that point, but if they indicate another region we should always trephine in accordance with the doctrines of cerebral localization rather than by the indication or the history of the lesion. Of course if there be a fistula discharging pus, we should trephine at the mouth of the fistula and follow it up to the abscess.

The dura having been opened, if there be an abscess the brain substance will probably bulge markedly through the opening. The normal pulsations of the brain will be absent. For exploration the grooved director is the best instrument to use. The hypodermatic needle and the knife have been used, but there is considerable danger of wounding the vessels, whereas the grooved director is safe in this respect, and as soon as the abscess is reached it will allow the pus to flow through its groove. The director should be forced gently and carefully straight forward into the brain in the probable direction of the abscess, and may be safely introduced to the depth of two to two and a half inches if the abscess be not reached more superficially. If the abscess be not reached, the director should be withdrawn exactly in the line in which it entered, and the brain similarly punctured in another direction. As soon as the abscess-cavity is reached, the knife should be used to open the abscess, and the opening may be enlarged by a pair of hemostatic forceps, introduced closed and drawn out expanded to a reasonable degree, so as to afford a free opening for the pus. The granulation-tissue lining the walls of the abscess-cavity should then be removed by the sharp spoon, care being taken not to do unnecessary damage to the neighboring parts of the brain. The cavity should next be very gently washed out, best with a boric acid solution, and a drainage tube inserted. This should be either of rubber or of silver. A buttonhole opening should be made in the scalp through which the tube may emerge, and the tube should be secured to the scalp by a silk thread. The bone should not be replaced. If the abscess is large and the first trephine opening does not drain it well in the recumbent posture, a second opening should be made, and the tube may pass through this or through both openings. An abundant sublimate dressing should then be applied. After two or three days the drainage tube may be gradually shortened until it can be dispensed with. Should there be reaccumulation of pus after apparent healing, the wound must be reopened, the pus evacuated, and the cavity washed out and treated as before. Sometimes such reaccumulation will occur two or three years after the first abscess.

If the first trephine opening does not disclose any abscess, and it is possible that one may exist at another point, a second, and if need be a third, trephine opening should be made at the possible point of suppuration. The dangers of additional trephining are nothing as compared with the dangers of an abscess, which is necessarily fatal unless evacuated.

In cerebellar abscess the upper edge of the trephine should be well below a line from theinion to the external auditory meatus (the line of the lateral sinus), and midway between the tip of the mastoid and theinion. The gouge may often replace the trephine to advantage, especially in children. It must be remembered that the skull is thin and quickly penetrated in this region.

The rongeur may be used to enlarge the opening if need be. The flap in the dura should have its base upward, to guard the sinus. The grooved director may be used again to penetrate the cerebellum, and even should the abscess exist on the opposite side of the cerebellum, it may be reached by an oblique puncture, care being taken not to injure the superior vermiciform process.

XV.—DISEASES OF THE BRAIN ARISING FROM SUPPURATIVE DISEASE OF THE EAR.

If we look at the base of the skull on the inside, we will be struck by the position of the petrous bone as a boundary-line between the middle and posterior fossæ of the skull. The upper edge forms a sort of watershed, with a moderate declivity in front toward the middle fossa, in which lies the temporo-sphenoidal lobe, and a sheer declivity at the back toward the posterior fossa, in which lies the cerebellum. The wall of bone between the tympanum and the middle fossa especially is very thin, and we can easily understand, on noting the anatomical relation of the temporo-sphenoidal lobe and the cerebellum to the petrous bone, how disease of the ear may readily break through the thin osseous barrier and produce inflammation of the meninges, thrombosis of the petrosal or lateral sinus, and involvement of either the temporo-sphenoidal lobe or the cerebellum itself. This explains the frequency of cerebral disease as a result of disease of the ear.

Barker estimates that there are not far from 2000 deaths annually from ear disease in Great Britain, with a population of but little more than one-half that of the United States. Of all these a very large proportion are caused by cerebral disorder resulting from ear disease. Of 43,730 cases of ear disease tabulated by Bürkner, 66.9 per cent. were disease of the middle ear, and 29 per cent. were suppurative middle-ear disease. Four-fifths of these were chronic, among which are to be sought the greater number of brain lesions. We are very apt to imagine that the excessively fetid discharges which often accompany ear disease are far more dangerous than those without such odor; but Röhrer has shown that the non-fetid discharges are the causes of the most dangerous cerebral sequels, since fetor is due to bacilli which are not pathogenic, but merely saphrophytic. Therefore the presence or absence of odor in the discharge is no test of its danger. Of all the discharges, the inspissated pus that is found in the ear in many cases is the most dangerous, being filled with pathogenic micro-organisms.

Primary acute inflammation of the ear rarely causes cerebral trouble: it is in the chronic cases that the danger lurks. In these, the mucous membrane being destroyed, the bone is bare and often carious and the seat of septic discharges and also of septic foci. Hence if we attack an ear the seat of such chronic discharge, and possibly of such inspissated pus and septic foci, we should be very careful to do it thoroughly and with the strictest antisepsis, or we may light up new and dangerous septic processes, giving to the inactive micro-organisms new life by the moisture supplied to them by opening the vessels and lymph-channels, and spreading them by breaking down the barriers to their introduction into the system.

It is a curious fact that aural disease may produce an abscess an inch or more from the inferior surface of the brain, the intervening cortex remaining perfectly normal. This may occur, according to Barker, in one of two ways: either a thrombus may extend into the lateral or the petrosal sinus, and from this through the veins that empty into the interior of the brain, especially as these veins have no valves; or, secondly, the blood-current may be reversed in these veins by reason of the thrombus.

Aural disease may cause meningitis, phlebitis, thrombosis of the lateral and petrosal sinuses, extradural abscess, or cerebral or cerebellar abscess. Of these, meningitis, pyemia, and abscess are the most frequent.

I. The **Meningitis** from aural disease differs in no respect from that arising from other causes, except that it is more likely to be localized and may be more frequently relieved by operation, as has already been indicated under that head.

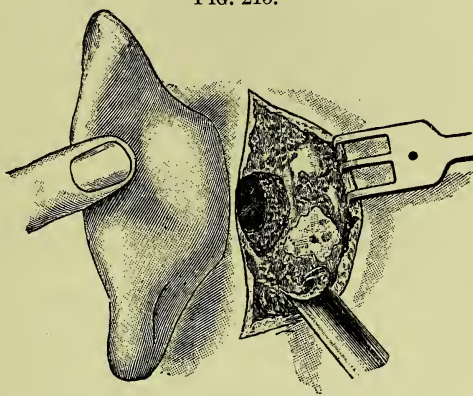
II. **Cerebral Abscesses from Ear Disease** are almost always situated in the temporo-sphenoidal lobe between two vertical lines, of which the anterior is drawn through the tragus, and the posterior two inches back of the tragus. Nine-tenths of them lie in a region covered by a circle of one inch and a quarter radius, the center of which is one inch and a quarter above and behind the meatus. This is well named by Barker the "dangerous region." They may be encapsulated or diffused. In other respects they do not differ from the cerebral abscesses already described.

Diagnosis.—The ear discharge from which they arise is almost always chronic, and may have existed for years. While the general health is good, there may be a sudden cessation of the discharge, with a rise of temperature, nausea and vomiting, and a dull ache in the mastoid region, the temples, and the neck; the pulse becomes frequent, the tongue foul, and very often there is diarrhea; that is to say, the symptoms of acute septic infection are engrafted on the existing chronic saprogenic suppuration. The headache and tenderness are often general or frontal, and not located at the site of the lesion. The temperature after the initial rise is again subnormal, and is in especial contrast to that of pyemia, with its acute fluctuations, which bear no relation to the ordinary morning fall and evening rise, or to the presence or absence of discharge, and may be accompanied with rigors. It is again in contrast to the high temperature of meningitis, which has not the abrupt oscillations of pyemic temperature. The intellect is dull and sluggish and deepens into coma. The bowels are apt to be constipated, the breath fetid, and the skin muddy, and there is marked emaciation. Optic neuritis, if present, is of value, but is often absent. Convulsive twitchings or paralysis are of great value, if present, by their localizing indications. The state of the pupil is not commonly to be relied upon.

Treatment of Abscess from Ear Disease.—The treatment of abscess arising from ear disease is the same in principle as that of cerebral abscess in any other region or from any other cause. Prevention of the cerebral disease is vastly better than treatment after its onset. Hence if after chronic ear disease persistent headache, vomiting, and mental dulness, without rise of temperature, occur, the mastoid should be opened as indicated below. Not seldom this will avoid the later necessity for graver operations. If, however, when first seen the intracranial symptoms have already arisen and the mastoid process has not already been opened, with few if any exceptions the first step should be to open the mastoid and thoroughly wash it out. In doing this as practised by Horsley and Barker a vertical curved incision should be made a quarter of an inch behind the meatus in the axis of the mastoid from its base to its tip, about two inches in length, the ear being drawn well forward. The mastoid antrum and cells should then all be thoroughly laid open by the gouge and chisel, and the posterior wall of the meatus be chiselled away to the cavity of the middle ear (Fig. 215). All the inspissated pus which is often found both in the mastoid antrum and in the mastoid cells, and which cannot be got rid of by simple syringing, should be removed by a small sharp spoon or a gouge and chisel, care being taken not to wound the lateral sinus. In order to reach the antrum the opening is best made from one-third to one-half of an

inch behind and the same distance above the center of the meatus (Fig. 216, $\times$). To find the mastoid antrum Macewen has directed attention to the value of

FIG. 215.



Opening the Mastoid Antrum (Esmarch and Kowalzig).

the "suprameatal triangle" which is formed by the posterior root of the zygoma above (dotted line, Fig. 217), the upper and posterior segment of the osseous external meatus in front (broken line, Fig. 217), and an imaginary nearly perpendicular line uniting these two (short nearly vertical line, Fig. 217). Within this triangle and toward its base the opening into the mastoid antrum may be made with safety. The

FIG. 217.

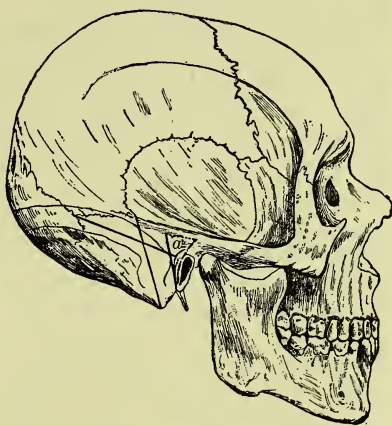
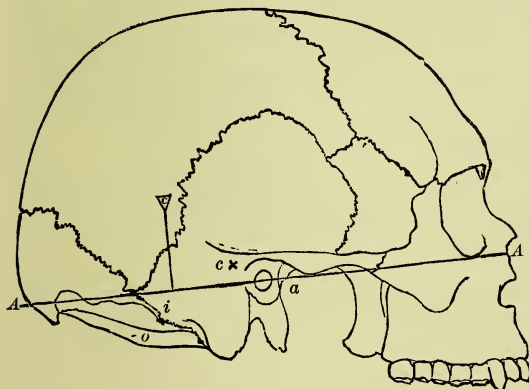


FIG. 216.



A, A, Reid's Base Line: a, the meatus; c, the point for trephining to reach an abscess in the temporo-sphenoidal lobe or to puncture the lateral ventricle $1\frac{1}{4}$ inches back of the meatus and $1\frac{1}{4}$ inches above Reid's base line; i, the mastoid vein; o, the point for trephining to reach an abscess in the cerebellum; $\times$, the point for trephining the mastoid antrum (Barker).

Surface Guides for the Sigmoid Sinus and the Suprameatal Triangle (Macewen): artificial lines drawn upon the skull indicating the following: (1) The short vertical line from the posterior border of the external auditory meatus to the posterior root of the zygoma marks the base of the suprameatal triangle (a); the broken line indicates the anterior border of the suprameatal triangle, its base being the dotted line marking a part of the root of the zygoma. This broken line also indicates the course of the facial nerve. (2) The second vertical line, extending from parieto-squamo-mastoid junction to tip of mastoid; the upper two-thirds of its length indicates the position of the sigmoid sinus. (3) The oblique line passing from asterion to upper limit of external auditory meatus indicates the posterior two-thirds of the sigmoid sinus from its commencement to its knee.

perforation is made slightly forward to avoid opening the sigmoid sinus (the curved part of the lateral sinus in the mastoid portion of the temporal bone,

Fig. 215). When the surgeon has penetrated to the depth of half an inch, he must be careful not to injure the facial nerve, the course of which is indicated by the broken line in Fig. 217. To avoid this he should "keep close to the floor of the middle fossa and nearer the posterior border of the opening, toward the posterior superior angle of the suprameatal triangle" (Macewen). The near approach to the nerve is often preceded by twitching of the facial muscles. The face should therefore be exposed, and an assistant be requested to observe any such phenomenon.

Of course the external meatus should also be well cleansed antiseptically. There is no objection here to the use of the 1 : 1000 sublimate solution, which, however, should not be used in washing out the cavity of the cerebral abscess itself. After having cleansed the ear it is well to inject the cavity with an emulsion of iodoform and to apply boric-acid fomentations, which are to be frequently changed.

Should this not relieve the symptoms very speedily, we must search for the abscess itself, which will probably lie in the "dangerous region." The best point to apply the trephine is one and a quarter inches behind and the same distance above the external auditory meatus (Fig. 216, *c*). One great advantage of this position is that it is far enough away from the ear to avoid septic infection from any aural discharge in case no abscess is present. It is better to use for the exploratory operation a small trephine, one-quarter or one-half inch, enlarging the opening, if need be, with the rongeur forceps or by a larger trephine.

The dura having been opened by a simple crucial incision, the grooved director should be inserted downward, forward, and inward in the direction of the opposite wing of the nose, as this is the axis of the temporo-sphenoidal lobe. Should the abscess not be reached, punctures may be made in other somewhat similar directions, and the cavity when found should be treated in the manner already described. Sometimes pus in the groove for the lateral sinus will ooze out through the opening for the mastoid vein (Fig. 216, *i*), which should be examined by turning back the scalp sufficiently to expose it. If found, of course the groove must be opened and the pus evacuated. The groove for the lateral sinus can safely be exposed to a large extent by means of the rongeur, gouge, and chisel. Of course great care must be taken not to wound the sinus, but should it be wounded it can be plugged and the hemorrhage, as a rule, readily controlled. Whenever it is necessary to expose the sinus, strips of gauze for plugging it should be within easy reach. In some cases it is desirable to open it deliberately. (See p. 528.)

III. Cerebellar Abscess.—Abscess of the cerebellum sometimes arises in connection with ear disease. It is usually situated in the anterior part of the lateral lobes where these are in contact with the petrous bone and the groove for the lateral sinus.

The general diagnosis for such an abscess is based on the same symptoms as that of cerebral abscess, except that the temperature may be high from complications, and choked disk is, as a rule, absent. Tenderness over the cerebellum, especially on percussion, and occipital headache if present, are both of value, but our means of positive diagnosis for cerebellar abscess are at present lamentably deficient. The point at which to trephine, as already indicated (Fig. 216, *c*), is midway between the tip of the mastoid and the inion, and well below a line drawn from the meatus to the inion, which line corresponds to the lateral sinus; or, in general terms, an inch and a half behind the meatus and one inch below Reid's base line—a line drawn from the lower border of the orbit through the middle of the external auditory meatus (Fig. 216, *a, a*). The surgeon

must remember that the occipital bone is very thin. A gouge may often replace the trephine.

The treatment of the abscess when once found is the same as that of cerebral abscess. In puncturing the cerebellum care must be taken not to injure the superior vermiciform process.

IV. **Extradural Abscess** is an abscess forming between the dura and the bone. These abscesses almost always arise from disease of the ear which has produced caries of the petrous bone. The abscess may be diffused over the dura or accumulated at one point.

The diagnosis from cerebral or cerebellar abscess or meningitis or thrombosis of the lateral sinus is not easy. The eye symptoms and the headache will be the same, but the temperature is in marked contrast to that of cerebral abscess, and will rise to 102° or 104° . The pain is usually above and behind the ear and is fixed, and the same point is markedly tender to percussion and pressure, the tenderness extending both back of the mastoid and above it. Not uncommonly there is oedema of the scalp. Extradural abscess should be suspected if the mastoid have already been opened without improvement and there be no signs of the cerebral irritation of leptomeningitis or the focal symptoms and low temperature of cerebral abscess, or of pyemia arising from thrombosis of the lateral sinus or the internal jugular. Symptoms of cerebral pressure are sometimes seen in extradural abscess.

Treatment.—If the mastoid has not already been opened, it should be done immediately and the cavity cleansed as before indicated. If a fistula exists from which pus escapes, it will lead us to the abscess. The dura should be laid bare, care being taken, of course, not to wound the lateral sinus. If a thrombus exists in the sinus, it should be opened and the clot evacuated and the sinus disinfected, either with or without ligation of the sinus as is thought best. The abscess having been reached, it should be cleansed with an antiseptic solution, the granulation-tissue lining its cavity curetted, any necrosed or carious bone removed, and free drainage provided.

Hoffman gives a table of 102 fatal cases in which the diagnosis was only made post-mortem. Ten other cases were diagnosticated during life, of which 8 recovered after operation. It is hardly necessary to comment upon such statistics.

V. **Pyemia and Thrombosis of the Lateral Sinus.**—Until recently these cases have been very rarely recognized, and when recognized they have been left without operative treatment, with the absolute certainty of a fatal result. It is not a common sequel of ear disease, but it is sufficiently frequent to demand that surgeons shall be acquainted with its symptoms and with its treatment, especially since Lane, Ballance, and others have placed the latter on a rational foundation. Sometimes pyemia may exist without thrombosis of the sinus, but commonly they coexist.

The symptoms will be a preceding history of chronic otorrhea, followed by headache and pain in the region of the sinus, vomiting, distinct and repeated rigors, violent oscillations of temperature, tenderness and local oedema over or behind the mastoid, and all the ordinary symptoms of pyemia. As the clot usually extends both in the course of the lateral sinus and soon into the internal jugular vein, there will be tenderness over the course of the lateral sinus—that is, in a line from the external auditory meatus to the inion—and also in the neck over the course of the internal jugular vein, which may feel like a tense, tender cord or may even have been destroyed. Choked disk will very likely be present.

The treatment should be prompt and positive. First the mastoid should

be opened and cleansed. Next the sinus should be exposed, and if there be any pus in the groove for the sinus, it should be washed away. If the sinus be thrombosed, it must be opened and thoroughly cleansed even to the torcular Herophili. Should it not be closed by the clot, and hemorrhage be very free, this may be controlled by instantaneous plugging with strips of iodoform gauze, which should be ready at hand. The internal jugular vein should then be exposed in the neck, and the vein should be followed down until a point *below* the thrombus is reached, which can usually be determined by touch with comparative ease. The vein should next be ligated, to prevent the extension of the septic thrombus downward to the heart and lungs, and it should then be washed out and made as aseptic as possible. Although in the nature of the case perfect asepsis cannot be obtained, yet the results have been such as to highly commend the treatment. Recovery has taken place in 56 out of 84 cases—66.7 per cent.—that have been operated on and reported. Without operation death is almost inevitable. Hence every case should be submitted to operation the moment the diagnosis is established.

The *petrosal sinuses* may also be thrombosed, but without local symptoms to guide us.

Sometimes the *cavernous sinus* is thrombosed, rarely from disease of the ear, but more frequently from infective inflammation about the orbit, the jaws, or the throat. If so, there will be hyperemia of the retinal veins and œdema in the region of the frontal vein and in the eyelids, with exophthalmos from retrobulbar œdema. The opposite eye is often in turn affected from extension of the thrombus to the opposite side. There may also be neuralgia of the first division of the fifth nerve and paresis or paralysis of the muscles supplied by the motor oculi (third), the abducens (sixth), or the pathetic (fourth) nerve, all of which run in the sinus.

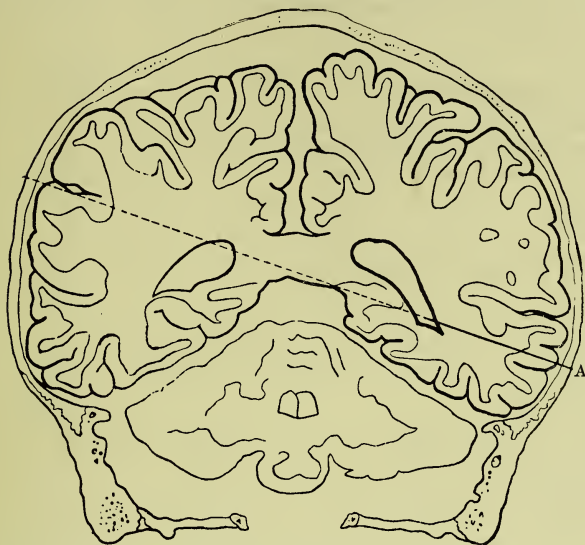
The **treatment** of these latter forms of sinus-thrombosis and of pyemia from ear disease, without thrombosis, must unfortunately be limited to the general treatment of pyemia.

XVI.—SURGERY OF THE LATERAL VENTRICLES.

Until of late it was supposed that any injury involving the lateral ventricles was necessarily fatal. This, however, is disproved by a number of cases in which the lateral ventricles have been opened by injury, such as simple fracture of the skull, of which there are at least 5 cases reported in children, of whom 3 recovered. In addition to these there are also recorded 7 cases of compound fracture with secondary implication of the ventricles, 4 of which recovered, and 2 of primary rupture of the ventricles by compound fracture, both of which recovered. Sometimes also in cases of fungus cerebri a communication is established with the lateral ventricles, followed by continuous discharge of cerebro-spinal fluid from the ventricles, in which recovery has taken place. Besides this, Keen has shown that puncture of the lateral ventricles through the brain substance can be done accurately, and that a drainage-tube may be introduced into the ventricles and remain several weeks without inflammation of the brain or its membranes, and that even irrigation of the ventricular cavities from side to side after bilateral trephining can be done without discomfort to the patient. Therefore in fracture involving the ventricles we should not infer that the patient must die and that we must do nothing, but should treat the case on the same antiseptic principles and by the same methods that we should employ had the ventricle not been invaded, and with a very reasonable hope of recovery.

If the ventricles are to be tapped, the lateral route is the best. A half-inch trephine opening should be made one and a quarter inches behind the external

FIG. 218.



Puncture of the Lateral Ventricle by the Lateral Route at A (Keen).

auditory meatus and the same distance above Reid's base line (Fig. 218, A). Then the grooved director or a small tube (caliber No. 5 of the French catheter scale or a little larger) should be thrust carefully and steadily into the brain in the direction of a point H vertically two and a half to three inches above the opposite meatus. If the lateral ventricle be of normal dimensions, it will be reached at a depth of two to two and a quarter inches, but if distended it will be reached at a less depth. The entry into the ventricle will be recognized by the instant diminution of resistance and by the escape of cerebro-spinal fluid. Drainage may then be effected, either by inserting a small bundle of horsehair doubled like a hairpin, with the rounded ends inserted first, and passed through the tube, or by carrying a rubber drainage-tube of the same size into the ventricle.

The operation has been done several times for chronic hydrocephalus, without, however, up to the present time, a single cure; but in acute hydrocephalus the result has been slightly more promising. Mr. Mayo Robinson has reported one case in which undoubtedly life was saved. Dennis has reported one case of evacuation of a clot in the lateral ventricles, but the laceration of the brain was such that the patient died soon afterward. A number of successful cases of operation for increased intracranial pressure have been reported.

Of course if the ventricles are tapped the asepsis should be absolute, or the result will necessarily be fatal.

XVII.—INTRACRANIAL TUMORS.

I. Their **cause** cannot, as a rule, be determined. Occasionally they arise from injury; in which case they are apt to be sarcomata, although they may be

fibromata or other varieties of tumor. Sometimes they are parasitic in origin, from the echinococcus or from the ray fungus (actinomycosis), and tumors of both of these varieties have been operated on successfully. Much more frequently, however, they arise from no assignable cause. Hale White and Bernhardt have gathered the statistics of 580 tumors, which are tabulated by Seguin and Weir, as follows:

	Number.	Per cent.
Nature of tumor not stated	133	22.9
Tubercular tumors	137	23.0
Gliomata	76	13.0
Sarcomata (including cysto-sarcomata)	75	13.0
Hydatids, cysticerci, and echinococci	30	5.0
Cysts	27	4.6
Carcinomata	24	4.0
Gummata	21	3.6
Glio-sarcomata	14	2.2
Myxomata (including myxo-sarcomata)	12	2.0
Osteomata	6	+1.0
Neuromata	4	—1.0
Psammomata	4	—1.0
Papillomata	4	—1.0
Fibromata	3	
Cholesteatomata	2	
Lipomata	2	
Erectile or vascular tumors	2	
Dermoid cysts	2	
Enchondromata	1	
Lymphomata	1	
Cases	580	

On looking at this table we see that the number of tubercular tumors exceeds twofold that of tumors produced by any other one cause. The sarcomata and gliomata, which are practically all sarcomata, taken together slightly exceed tubercular tumors. Of the 580 tumors in this table, the nature of 447 was known. The tubercular and these two kinds of sarcomata numbered 288, leaving, therefore, only 159 for all the other known kinds of tumor. Tubercular tumors are most frequent in early life. Three-fourths of them occur before the twentieth year, and one-half before the tenth, according to Gowers. On the contrary, the various forms of cancer, including sarcoma, are more common from twenty to forty years of age.

II. **Location.**—Of 637 intracranial tumors tabulated by Gowers, 297 were situated in the cerebral hemispheres, excluding the central ganglia, 179 in the cerebellum, 59 in the pons, 48 in the central ganglia, 31 in the medulla, 13 in the corpora quadrigemina, and 10 in the crura cerebri. Starr found 96 tumors of the cerebellum in 300 cases of intracranial tumors in children only.

III. **Infiltration.**—Some tumors are definitely limited either by a distinct wall, as in a well-defined cyst; in others, as in a fibroma or an osteoma, the limits of the tumor, though without any such wall, are definite and abrupt; but malignant, and to a less extent tubercular, growths of the brain, as of other parts of the body, are more apt to infiltrate the surrounding tissues without any well-defined margins. This, however, is not always the case. When infiltration exists, the need for removal of more tissue than that which constitutes the tumor itself is very apparent. The probability of recurrence is also much greater in such cases.

IV. The **symptoms** of tumor are in many respects similar to those of other lesions. They may be caused either by irritation or destruction of the cerebral substance or by pressure upon the brain. They are either diffused or localized.

1. *Headache* is, as a rule, early, constant, and severe. When the tumor is superficial the headache is apt to correspond to the site of the disease. While, like all the other symptoms of tumor, it may be absent, yet in the great majority of cases it is present, and is usually one of the most annoying and painful symptoms. As a rule it is diffused, but even if it is localized we must not depend upon it too much as an indication of the site of the tumor.

2. *Pain* is almost always present, and may either be spontaneous or be evoked by pressure or percussion. As a localizing symptom, pain, like headache, is not of great value. Pain, however, which is not spontaneously complained of, but is produced by percussion, is of more value than spontaneous pain or pain upon pressure.

3. *Vertigo* is a common symptom, although not constant, but is more marked probably in cerebellar tumors than in cerebral. If the tumor is in the cerebellum, the vertigo is apt to be present in the recumbent posture as well as in the erect.

4. *Vomiting*, if cerebral in origin, is of considerable value. By cerebral vomiting is meant that variety which has no relation either to the ingestion of food or to a furred tongue, constipation, diarrhea, or other evidences of disturbed digestion.

5. *Epileptic convulsions* usually set in as soon as the tumor is of sufficient size to produce pressure. They are often general in their distribution, but occasionally they are localized, and if so they are of great value; for if the attack begins always in the same arm or on the same side of the face or in the same leg, they point with reasonable accuracy to the location of the tumor.

6. Another of the pressure symptoms is *choked disk*, which in tumor is nearly always double. It sets in probably as soon as the tumor has reached any size, but while its existence is of value, as indicating the presence of a tumor, it gives no indication of the position, character, or size of the tumor. If it be monocular—that is, in one eye only—the tumor is most likely to be in the opposite hemisphere, but if optic neuritis and choked disk exist in both eyes, as is almost always the case, the site of the lesion is probably the side on which the least swelling occurs; and this may be especially inferred if the other symptoms point in the same direction. Strange to say, it does not interfere with the acuity of vision until secondary atrophy of the nerve has taken place.

7. *Other Eye-symptoms*.—Paresis of any single muscle or any group of muscles generally indicates either pressure from a coarse lesion in the cortex which supplies this muscle, or true infiltration of pathogenic material into the meshes of the nerves themselves. Unless, however, associated with other symptoms, it is of little value. Spasm of any of the muscles is of more value than paresis or paralysis, and indicates more positively a lesion in the motor centers of such muscles. Homonymous hemianopsia is of great value, since it generally indicates a lesion of the cuneus on the same side. The term hemianopsia denotes a condition in which, each retina being divided by a vertical line into two halves, the right half of each retina is insensible to vision, and therefore objects in the left half of the visual field are not seen; or, *vice versâ*, the left half of each retina is blind, and then the right half of each visual field is not seen. If the right cuneus is involved, the right halves of the retinæ will be blind and the left halves of the visual fields not be seen, and *vice versâ*.

The pupils are not uncommonly unequally dilated or contracted. Their condition is of little value in pointing out tumor in contrast with any other intracranial disease.

Focal Symptoms.—1. *Hemianopsia* has already been mentioned.

2. *Aphasia*.—If the tumor be located in the third frontal convolution, on

the left side in right-handed persons, and on the right side in left-handed persons, as a rule, motor aphasia will be marked.

3. *Paresis or Paralysis*.—If the tumor be located so as to press directly upon the face center, arm center, or leg center, or if it be even some distance from these and yet large enough to exercise distant pressure upon them, there may be paresis of the arm or leg or even a partial or complete hemiplegia.

4. *Anesthesia*.—Unless the internal capsule is involved, anesthesia is rare; yet it sometimes does occur. Tumors pressing upon the olfactory or any other nerve or involving the nucleus of any nerve or nerves will produce at first irritation and afterward destruction of the function of such nerve or nerves.

Mental Disturbances.—As a tumor increases in size, stupor, and finally coma, almost always precede death. Earlier in the history of the disease, however, there are mental disturbances, such as hallucinations and delusions, and in most cases there is a general loss of mental acuteness, with loss of memory and more or less childishness. Resemblance of the symptoms to hysteria should not lead the surgeon to overlook a possible organic disease. Among other mental disturbances, the following should be mentioned:

1. *Word-deafness*, or, as it is often called, sensory or amnesic aphasia, is the loss of memory of the sound of a word. For instance, a spoken word, such as "cat," would not convey its proper meaning to the patient. Word-deafness generally indicates a lesion in the posterior half of the first temporal convolution on the left side.

2. *Word-blindness, alexia*, is the loss of memory of the appearance of a written or printed word. For instance, again, a written or printed word "cat" would be unintelligible to the patient. This defect usually indicates disease of the lower posterior portion of the parietal lobe on the left side, and especially the angular and supramarginal gyri.

3. *Agraphia* is the loss of memory of the muscular movements made in writing, so that the patient has lost the faculty of writing, though he still retains control of the muscles involved in this act. It usually indicates a lesion beneath the motor speech center (Broca's convolution), or possibly of the posterior part of the second frontal convolution.

4. Again, there may be loss of perception of the use, odor, color, or taste of any object presented to the mind. This general symptom is often termed *apraxia*, and of course has as many varieties as there are avenues by which the mind may be reached; for instance, sight, touch, smell, taste, hearing for language, hearing for music, etc., any of which may be lost, producing mind-blindness, mind-deafness, etc. The patient in mind-blindness will be unable to recognize an object by sight, but may still be able to recognize it by touch. All these various conditions should therefore be examined. Apraxia will generally indicate a lesion in the supramarginal or angular gyrus in the left hemisphere in right-handed persons, and *vice versa*.

V. Diagnosis.—That there is need for more exact means of diagnosis is very evident when we remember that in a number of cases an operation has been undertaken for a tumor supposed to be located at a certain point, without finding the tumor, and the post-mortem has shown either that the tumor existed elsewhere or that there was no tumor whatever. Time is enabling us, however, gradually to become more accurate in our diagnosis. There are six questions (Weir and Seguin) to which, if possible, we must obtain answers in any suspicious case:

1. *Does a Tumor exist?*—The symptoms, briefly stated, will be headache, pain, possibly vertigo, cerebral vomiting, convulsions either general or localized, and paresis or paralysis to a greater or less extent, choked disk, possibly

stupor toward the end of certain cases, hemianopsia, and apraxia or aphasia, with or without anesthesia. While all these will not be present in any one case, if there be a reasonable number of them the probabilities of tumor will be very strong. The differential diagnosis between tumor and abscess has already been given on page 523. In Bright's disease, and sometimes in lead-poisoning, there may be headache, vomiting, convulsions, and choked disk, but the examination of the urine and the usual dropsy in Bright's disease, and the wrist-drop and condition of the gums in lead-poisoning, together with other symptoms of both disorders, should put us on the right track.

2. *What is the Location of the Tumor?*—This question must be answered by the localizing symptoms above given, if they exist; for it must be remembered that in certain parts of the brain a tumor may exist without any localizing symptoms, but with only the general symptoms of headache, vomiting, choked disk, and convulsions. These latent zones are especially the anterior portion of the frontal lobes, the temporo-sphenoidal lobe except on the left side in part, a considerable part of the parietal and occipital lobes, and to some extent the cerebellum. Sometimes even a very large tumor may exist and give no signs of its presence, but if it be in certain localities where the centers for the special senses are located, or in the cortical centers for motion, or in the paths of distribution of the nerves from these centers, we may be able in most cases to locate it with reasonable accuracy. If in the history a number of centers have been successively involved, this fact is very important, as the history of the march of the paralysis or the irritation is of the greatest value in enabling us to locate the tumor. Rapidly-produced blindness is usually due to tumors, especially in the cerebellum or pons, which obstruct the veins of Galen or the straight sinus or the *iter e tertio ad quartum ventriculum*, and so produce an internal hydrocephalus, pressure on the optic tract, choked disk, and later blindness.

3. *At what Depth does the Tumor lie—that is, is it cortical or subcortical?*—A tumor in the cortex may be diagnosticated possibly by tenderness to pressure over the area of the tumor, possibly by a local rise of temperature, and also by considering the number and relations of the centers involved by the tumor and the absence of anesthesia.

4. *Is the Tumor Single or Multiple?*—As a rule, if multiple, operation will be contraindicated; but if single, its removal may be attempted unless specially contraindicated. If single, the localizing symptoms should be referred either to one center if the tumor be small, or to several adjacent centers if it be large. If the centers involved are multiple and far apart, the probabilities are against a single tumor and in favor of a multiple; or if single, the tumor will be very large.

5. *What is the Size of the Tumor?*—In a few cases this has been diagnosticated. The tumor is probably small if only a restricted area of the brain is involved, as shown by a limited paresis or paralysis, if with time no adjacent centers have become involved, and if the symptoms of intracranial pressure are either slight or absent. A large tumor can be diagnosticated by the involvement of a large number of neighboring centers and marked symptoms of pressure. Often this diagnosis, however, cannot be made before operation. Even if the tumor be large it may be removed successfully. Thus Horsley has removed a tumor weighing over four ounces, and Weir and Keen have removed two others but little short of this weight; and two of these three patients recovered. We should therefore hesitate before refusing to operate, even if the tumor be probably of large size. Refusal means with practical certainty a fatal termination. Operation, it is true, may be followed by death,

but this would only be anticipating by a little time the natural termination of the disease, and it gives the only hope. If the tumor is found to be too large for removal, the surgeon will of course terminate the operation, and, as shown by a number of cases, the patient may be decidedly the better by reason of the interference, especially from the relief to the headache, blindness, vertigo, and vomiting. In one of Horsley's cases, in which for inoperable cerebellar tumor he removed half of the occipital bone, the relief to the dyspnea, headache, and rotary convulsions was so great that the patient requested the removal of the other half, and his life was prolonged for two years in relative comfort.

6. *What is the Nature of the Tumor?*—If the patient has suffered from cancer, tubercle, or syphilis and the symptoms of intracranial tumor are present, it is most likely that the cerebral tumor is of the same nature as the disease already existing elsewhere. We can always make a guess based upon the facts that before twenty years of age tubercle is much more frequent than any other disease, and that between twenty and forty glioma and sarcoma are more frequent than other tumors; but such a guess is hardly one upon which we should act. Hale White and Von Bergmann have both opposed operation in syphilitic tumors, but the view of Seguin is that if the antisiphilitic treatment has been inefficient, including the administration of increasing doses of the iodides up to half an ounce a day, operation should be attempted. Horsley limits such trial of internal remedies to six weeks, after which he would proceed to operation. A gumma which has undergone a fibrous change and has resisted such vigorous specific treatment is practically a permanent tumor, and whether it shall be attacked or not must be determined on precisely the same grounds as any other tumor. Tubercular tumors are more apt to be multiple than any other variety, and we should therefore hesitate somewhat more as to them.

VI. *Prognosis.*—If an intracranial tumor be not operated upon, it is almost necessarily a fatal disease, with the exception of those syphilitic growths which yield to the iodides. It is possible that life may be very much prolonged in some few cases, but in the majority a few months or a year or two is all that can be expected. Hence, as it is so almost uniformly fatal, and as operation has given such good results, it is proper that we should operate, unless the multiplicity, depth, size, etc. present positive contraindications. If we operate, the prognosis varies much, first as to immediate recovery, and secondly as to ultimate recovery.

1. *As to Immediate Recovery.*—Chipault's statistics (1894) include 67 operations for intracranial tumors, of which 47 recovered and 20 died. In addition to this, 47 cases of exploratory operations in which the tumor was not found gave 35 deaths and 12 recoveries. The chief reason for the fatality of this last condition has been probably too extensive exploration in search of the tumor or for its removal. If no tumor is found after cautious search by knife, grooved director, and the gentlest use of the little finger, or if, being found, it is not removable, the operation should be terminated at once, especially if there is much bulging, indicating a large tumor. In 7 cases in which trephining was done for the relief of the increased intracranial pressure caused by the tumor, recovery followed in all. Probably time, by perfecting both the diagnosis and the operative methods, will enable us to improve upon these results. At the same time, it must always be recognized that an operation for cerebral tumor is a very serious one, not to be undertaken lightly nor without explaining the entire matter carefully at least to the family: the mental condition of the patient may be such that it would be unwise or useless to explain it to him.

Another important reason for the mortality has been the delay in operating.

Physicians, who almost always see these cases first, postpone consulting a surgeon for an unreasonably long time, in the vain hope of improvement. It cannot be too strongly insisted on that we should treat tumors of the brain just as we treat tumors in other parts of the body—as a rule, remove them at the earliest possible moment. In the brain the reasons for early operation are even more cogent, for the soft tissue here is more easily injured, it cannot escape from pressure as do the soft parts not enclosed in such a bony case, and the growth of the tumor is insidious and not easily discovered, as it is when accessible to the eye and the finger. We can only infer its growth from the symptoms. When a tumor is diagnosed and located with reasonable certainty, if it be probably amenable to operation, its removal by operation should be attempted as soon as drugs have been fairly tried and proved of no avail. The limit for this “fair trial” Horsley, as stated above, puts at six weeks, and certainly this is enough. After that it is but wasting time and imperilling life to wait longer. Further time only allows of increase in the size of the tumor, with wider infiltration of brain tissue or wider destruction by pressure, and the operative dangers and difficulties increase with each week or month of delay. If the tumor is not removable, the opening in the skull should not be closed by replacing the bone. This partial operation will often be an immense comfort. In tumors of the cerebellum operation for their removal has been followed by a fatal result in three cases out of five. Their proximity to the fourth ventricle, the tubercula quadrigemina, and the pons, with the important and vital centers lying there, makes operations in such cases peculiarly hazardous. But great relief can be given by wide removal of the bone, as already stated.

2. *As to Ultimate Result.*—If the tumor be malignant, it will return, as a rule. In tubercular or syphilitic tumors the probability of a permanent cure is good. In benign growths recurrence is not to be expected. In estimating the future of such patients it must be remembered that the tumor during its growth has done a certain amount of damage, just as a bullet that has lodged has inflicted a certain amount of injury in its pathway to its resting-place. The removal of the bullet or of the tumor will not affect the damage already done. Hence if an optic neuritis, for instance, has continued long enough to be followed by atrophy of the optic nerve, it is hopeless to expect that the blindness will disappear, though vision may improve greatly even if the tumor has existed for years. So also the paralysis of an arm or a leg from pressure on its center may remain, though in the majority of cases the motor function has been to a great extent restored. If the epileptic habit has been formed, the removal of the tumor will probably modify and may possibly cure the attacks, but they will often persist, though they may be less frequent and milder.

VII. *Treatment.*—When it has been decided that the tumor exists in a given locality, and that it is amenable to operation, the operative procedure may be very briefly described.

1. A large semilunar flap is made, with the center corresponding to the site of the tumor. 2. An opening not less than an inch and a half in diameter is made in the skull, by the trephine, the chisel, or otherwise, as may be deemed best. 3. The dura should be opened. 4. The tumor, having been recognized, should be enucleated, if possible, by the finger. This will very rarely be practicable. If not, the knife, the scissors, the sharp spoon, or the handle of an ordinary teaspoon may be used to remove it, either as an entire mass or piecemeal. 5. If the tumor be subcortical, an incision should be made in the brain and the little finger inserted with great gentleness to recognize the resistance, size, etc. of the tumor. When found it is to be removed as before described. 6. If the tumor be so large that it would be

unwise to remove it, the operation should be immediately terminated and the dura and flap secured, the bone not being replaced. 7. The operation is often best done in two stages (p. 489). 8. The method of dealing with hemorrhage and the other steps of the operation differ in no wise from those described under the head of Technique.

XVIII.—EPILEPSY.

From a surgical point of view cases of epilepsy are either traumatic or non-traumatic.

I. Epilepsy following Traumatism.—As a rule, the epileptic attacks do not make their appearance until some months or even years after the accident, and the earlier attacks are not only less frequent than the later ones, but are often unattended at first by loss of consciousness (*petit mal*), and only after a time become fully-developed epileptic attacks. There is reason to believe that even slight accidents may sometimes produce epilepsy, presumably through the agency of a cicatrix in the dura or in the brain. Very often in such cases there will be lesions of motion and sometimes of sensibility, perhaps dating back to the time of the accident. It is probable also that if after compound fracture any portion of bone remains depressed, it may irritate the underlying cortex and cause epilepsy. Similarly, in some cases apparently by reason simply of the presence of the resulting cicatrix, epilepsy may follow. Hence one argument for the radical treatment of such injuries at the time they are received, as has been advocated in preceding pages. The numerous cases reported in the periodical literature of the last few years constitute a very strong reason for the propriety of thus interfering in the way of prevention of the epilepsy, rather than allowing it to set in and then trying to remedy it.

Sometimes the cicatrix in the scalp is tender or is the seat of radiating pains and sometimes of the aura. Pressure on it may produce a fit, although most frequently it will not. Very rarely there will arise from a traumatism a sarcoma, fibroma, or other form of tumor which itself will cause epilepsy. Apparently mere alteration in the texture of the cortical tissue from fatty or other degenerative changes following traumatism may itself give rise to the epilepsy. Mr. Horsley especially has shown not only that such brain scars, scars in the dura, cysts, fragments of bone, etc., are presumably the cause of such epileptic attacks, but also that their removal has resulted in relief and even in cure.

In cases of epilepsy arising from traumatism, if the trauma is shown by a scar or by evidence of injury to the bone without a scar, the injury may be, first, over well-known centers, motor or otherwise; or, secondly, it may lie over the so-called latent zones of the brain.

In those cases in which *the lesion lies over well-known centers and the epileptic fit is limited to the muscles corresponding to these motor centers*, the inference is that they stand in the relation of cause and effect. But it must always be remembered that the irritation of the scar in the scalp is sometimes sufficient to cause the epileptic attacks, and hence, as a rule, the proper course of procedure is to prepare for a complete trephining with the same minute care that has heretofore been described as necessary in cerebral operations; but if an exploratory incision exposing the bone under the scar shows no injury sufficient to make us think the brain is certainly injured, we should limit the operation to the excision of the scar. Especially will this be proper if the scar be the site of tenderness on pressure and of the epileptic aura, or if pressure on the scar produce a distinct fit. In a moderate number of cases now reported in which there existed no fracture of the bone, but only a scar in the scalp, the excision of the scar has been followed by cure.

Moreover, we must remember such cases as the one related by Briggs, in which a girl had both an old depressed fracture of the skull and necrosis of the tibia. He very wisely first operated on the tibia, and after five years the fits had not recurred, showing that their origin was not in the depressed fracture of the skull, which *prima facie* was the probable cause, but in the irritation of the tibial disease. We should not, however, be too hopeful if the fits cease immediately after the excision of the scar or after any other operation. It is a strange fact, to which White has recently called renewed and especial attention, that any operation, even though trivial, is apt to cause the cessation of the fits for weeks or months; and hence after removal of the scar we cannot be certain that the epilepsy is cured until at least three years have elapsed without the return of the attacks. The surgeons of the largest experience are probably the most cautious in drawing too favorable conclusions.

If excision of the scar does not cure the patient, and the scar lies over the motor center which corresponds to the initial muscular spasm, and still more if there is evidence of any depression of the skull or of an old compound fracture, a second operation should be done and the patient be trephined. The lesion rarely will be a splintering of the inner table, sometimes with a depressed fragment of bone; sometimes a cyst following a blood-clot, or not uncommonly simply a brain scar, with generally a corresponding cicatrix in the dura. Occasionally, however, nothing more than thickening and eburnation of the bones of the skull will be found.

After trephining the skull, the dura should always be opened, even though it be sound, in order to inspect the brain. If there be a scar in the dura, it must be excised, and if there be one in the brain, it should also be excised down to the white tissue. In such cases it is of the utmost importance to remember that *all* the damaged brain tissue must be removed. It is better even to trench somewhat upon apparently healthy brain tissue, for the removal of a little more tissue than is necessary is preferable to the opposite error of removing less than is necessary, with possible retention of the epileptic fits. In effecting this removal it is important also to remember that we can extend our incisions in the antero-posterior direction much more freely than we can in the vertical direction, for extension in the vertical direction means involvement of other motor centers, whereas extension antero-posteriorly will probably merely add to the completeness of the removal of the injured center. It is not, as a rule, necessary to go deeper than the gray substance, unless we find evidence of a scar or other lesion at a greater depth. Care must be taken to arrest the hemorrhage, as has been already mentioned in the section on Technique, the ligature being the chief reliance, and pressure and hot water coming next in efficiency. Large veins should be ligated before division, or, better still, should be avoided, as is often possible, by going around them or by lifting them and working under them. If any of the dura has been removed, its place should be supplied, as has been suggested, by a bit of the pericranium. This is especially important in cases where the brain has been incised, so as to avoid a fungus cerebri. Drainage, as a rule, may be omitted. The bone should not be replaced if it would probably produce pressure on the brain. Otherwise it may be put back, not only the large piece removed by the trephine, but a number of the small pieces as well. All these should have had the care described in the section on Technique, in order to preserve their vitality. If the bone is diseased, of course it should not be replaced, nor if it is irregular and would produce irritation or pressure. Possibly experience may show that it is best not to replace it at all; this is yet an open question.

In those cases in which *the lesion does not lie over well-known centers of motion, special senses, language, etc., but over the latent zones*, the scar should still be excised as above advised, but the surgeon should always be prepared to do a complete brain operation as well as simple excision of the scar, for he can never tell how far it may be wise to extend the operation until after he has lifted the scalp and inspected the bone. If excision of the scar, as before, does not effect a cure, and there is distinct evidence, as above stated, either of fracture or of irregularity of the bone, or if the scar is tender or the seat of an aura, or if a fit follows pressure upon it, trephining should be done. Once the bone has been removed, the dura should be opened, and then what is to be done either to the dura or to the brain must depend on what is found. Any dural scar, brain scar, altered brain tissue, or cyst should be treated by excision. Sometimes in cases of compound fracture trephining will have been done at the time of the accident and yet epilepsy will develop later. In such cases, whether the lesion be over the motor or other well-known centers or over the latent zones, as a rule it will be proper to lift a flap of scalp, enlarge the bony opening if necessary, and examine the brain. Trimming the thickened bone away from the edges of the opening left by a compound fracture or a former trephining, or the removal of any of scar tissue, will often effect a great improvement, and in some cases even a cure. Secondary operations of this kind have sometimes proved very successful. In all such operations as this it must be remembered that if we undertake an operation at all it must be done thoroughly. A large trephine may be used, one and a half inches in diameter, or else several small trephine openings should be made, and enough of the bone between them be removed to enable us to see the brain tissue well. Timidity in this respect will often result in a fruitless operation where a bolder course might have achieved success. In operations on the brain it is always important to have plenty of room for inspection of the brain, for determination as to what should be done, and for facility in dealing with hemorrhage.

In all cases of epilepsy it is important that the operation should be done at an early date, in order to prevent secondary sclerosis and the formation of the epileptic habit, a point on which Sachs has laid especial stress.

II. NON-TRAUMATIC EPILEPSY.

1. Jacksonian Epilepsy.—This term is applied to those cases of epilepsy in which there is spasm of a certain limited group of muscles *without loss of consciousness*, and in which, therefore, the discharging lesion seems clearly to be limited to the center corresponding to the muscles involved. In a number of such cases these centers have been exposed, then recognized by the battery as already described, and the entire area excised. The time has not yet come when a definite opinion can be expressed as to the value of these operations. The danger to life is not very great. A large number of the cases have not been bettered, but in many great relief has followed both in diminished severity and diminished frequency of the attacks.

Some cases have been reported in which momentary faradization of the cortical centers which are evidently diseased has produced a fit entirely analogous to the typical epileptic fits to which the patient has been a victim. Such momentary faradization of a normal cortex should produce only a single movement of the part supplied by that portion of the cortex. Whether this will be of value in determining that a cortical centre which appears to the eye and touch to be healthy is really diseased, is a matter to be decided by a larger experience.

The question naturally arises whether this excision will not produce palsy of the muscles supplied by this center. Complete primary paralysis of these muscles always follows such removal, and not uncommonly the pressure of the clot or of the exudate formed after the operation will paralyze neighboring centers, so that there may be complete hemiplegia in many cases resulting from simple excision, for instance, of the arm center. But it is an invariable rule that this hemiplegia is but temporary. After a few weeks the patient will begin to regain control over the muscles, and eventually he will regain motion in its entire range, but usually with some lessened muscular strength; that is, there is a certain paresis remaining. Whether this regain of muscular control is due to the cortical center on the opposite side of the brain taking up the work of the lost center (as the left hand may take up the work of the right after amputation), or to a regeneration of brain tissue, is at present in doubt, with perhaps a preponderance of testimony against regeneration of the cerebral tissue. Experimental transplantation of brain tissue itself from one animal to another has been done with good results from an operative point of view. Whether this can ever be applied to man is unknown.

One precaution is very essential in these cases. Many patients will describe a fit of the Jacksonian type (without of course using this term), which description a closer observation will show to be wholly erroneous. In fact, so absorbed are the relatives of an epileptic in seeing that he does not injure himself, and in sympathetic care for him, that in most cases they are the worst possible witnesses as to the character of the attacks. Hence no patient should be operated on for epilepsy unless his attacks have been seen either by the surgeon himself or by a competent and trained nurse—if possible, one who has been accustomed to observe such fits. Members of the family, moreover, are not trained observers, and for scientific accuracy such training is essential. It is essential that the nurse should be instructed by the surgeon to do absolutely nothing but observe and immediately record the phenomena observed in each fit. Cold, hard, scientific facts are what we want, not sympathetic statements. In true Jacksonian epilepsy the patient himself, if a reasonably careful observer, can give much help, because he does not lose his consciousness.

The observations above referred to should cover, first, what muscles are first involved, and, secondly, the march of the fit; that is to say, the fit having started at such and such a point, whether it extends to other points in any definite order, and whether this order is the same in different fits. Thirdly, the state of the pupils should be very carefully observed, whether dilated or contracted, whether equally so, whether responsive to light stimulus, etc. Lastly, as soon after an attack as the patient is capable of using the dynamometer it should be employed to determine the comparative strength of the muscles, especially of those first involved, which in such cases are apt to be parietic in consequence of exhaustion from the spasmodic motion.

2. Focal Epilepsy.—In a certain number of cases in which there has been no lesion of which there was evidence by scar, depressed bone, or other signs, in which there were unconsciousness and general epileptic spasm instead of monospasm (*e. g.* of an arm or a leg), but the attacks always began in a certain set of muscles, as if they always had their origin from the cerebral center dominating these muscles as a focus, from which they radiated to other centers, an attempt has been made to prevent their recurrence or extension by removing the center corresponding to the muscles in which the fits start. In these cases, even more possibly than in those of the Jacksonian type, it is necessary to have reliable and repeated observation of the attacks before deciding to operate. Even with the diminished dangers of modern cerebral surgery, exposing the

brain, and especially excising a cortical center, is not a trifling operation, but a serious one, which must not be undertaken without the best evidence of its necessity. No member of the family, no friend, no one but a trained observer, must be trusted to determine these facts. The testimony of the family may be taken as a corroboration, but not as a foundation. Moreover, it has been well pointed out by Putnam that the value of spasms starting in the hands is not so great as where the spasm begins in a less easily disturbed part, as the elbow or the shoulder. The finger motions are highly specialized, and therefore their equilibrium is much more easily disturbed than, so to speak, the more phlegmatic, coarser, better-balanced muscles of the larger joints like the shoulder. If, therefore, in focal epilepsy the muscles of the shoulder are those first involved, the spasm extending from the shoulder finally over the whole body, such a case is far better suited to operation than one in which the more easily unbalanced muscles of the hand, thumb, etc. are the site of the initial spasmodic movement. In other words, the equilibrium of the hand is more easily disturbed than that of the shoulder, and is therefore of less value as a factor in determining us in favor of operation. Results seem thus far to indicate that in a small percentage of cases, which can scarcely as yet be stated numerically, a cure may possibly be effected. In a number of cases, much larger than in the last class, considerable improvement will follow; in an equal or still larger number no betterment will follow. The operation, however, does not seem ever to produce an increase in the number of attacks. The percentage of deaths in the reported cases is not large, yet danger is a factor in the decision of the question whether an operation shall be done or not, which must on no account be omitted in the statement of the case to the patient and the family. Epilepsy is so direful a disease that there are few parents or patients who would not be willing to face a large risk to life for the reasonable probability of betterment, and still more if there be a chance of cure, however small; and they are all the more willing when there is but slight chance of death and none of being made worse.

In these cases it is especially important always to make a large opening in the bone, in order, if possible, to recognize the convolutions. When the brain is exposed, no antiseptics should touch it until the battery has well defined the center which is to be identified and removed. In faradizing the brain the current required is about that which is necessary to call the muscles of the thumb into action, and stronger currents should be avoided: although no serious injury to the brain has thus far been reported as a result of such faradization, yet its possibility should lead us to use as gentle a current as will effect our object. The faradization should not be repeated any oftener than is necessary.

Horsley has especially insisted here on thoroughness of excision. If any of the center be left, the operation will probably prove a failure. When the center sought for has been found and its limits determined, any large veins involved in its excision should first be tied, and then the center limited by incisions made with a sharp knife held vertically to the surface. This should penetrate to the white substance. The cortex may then be removed either by scissors or by knife. Sometimes we can strip off or push away the pia and its vessels from the underlying convolutions, and so avoid wounding any large vessels. It will rarely, if ever, be necessary in cases of focal epilepsy to remove any of the dura. After the excision, therefore, this should be carefully replaced and secured by sutures, and the operation terminated as heretofore described.

Unfortunately, the large majority of cases of epilepsy belong rather to so-called general epilepsy than to focal, Jacksonian, or traumatic. Such cases are evidently unsuited to any operation, and in our new-born boldness,

begotten of success in cerebral surgery, we should not overstep the limits of prudence and operate indiscriminately and unwisely. Each case of epilepsy must be studied by itself for days, and sometimes even for weeks, before we reach a definite conclusion that it is wise to operate. The surest way to discredit cerebral surgery is to practise unwise cerebral surgery. Hence, while advocating a more radical treatment than that formerly thought to be wise, we must be careful not to proceed to the opposite extreme of indiscriminate operative interference. A progressive conservatism, if the term is allowable, should be our rule.

XIX.—TREPHINING FOR INVETERATE HEADACHE, INSANITY, AND ARRESTED DEVELOPMENT.

I. Inveterate Headache.—Occasionally headache will be fixed in its locality and of an excessively severe type, so that it will interfere seriously with the patient's health and happiness, and may even make any occupation impossible. The cause of such a headache is often traumatism, resulting in disease of the bones. The possible existence of hysteria, gout, or syphilis should always first be considered, and the family and personal history therefore should be investigated with great care. As a rule, especially in the case of a hysterical woman, we should refuse to undertake an operation until a thorough trial of all the remedial means at our command for such diseases has been carefully made by a competent neurologist. If then no relief has been afforded, in view of the very small risk to life involved in simple trephining it is proper that it should be done. Trephining having been done, it is better, usually, to open the dura and inspect the brain, even if nothing further be attempted. It is not wise, as a rule, to go so far as to trephine a patient and then neglect the information which may be derived from the simple opening of the dura. Properly done, this adds practically little to the risk and may add immensely to our knowledge. If nothing is found, the dura should be sutured in place, without replacement of the button of bone.

II. Insanity and other Mental Disturbances.—The most remarkable case in which a psychical disturbance has given a clue to the diagnosis is reported by Macewen. The man had been injured, and a year later suffered from melancholia and a tendency to homicide. There were no motor phenomena whatever, but it was discovered that for two weeks after the accident he had suffered from the form of apraxia called mind-blindness. Vision was perfect, but what he saw conveyed no impression to him. His New Testament was recognized by touch, but on opening it the printed words had no meaning for him. A lesion in the angular gyrus was diagnosed, and on operating it was found that a portion of the inner table had been detached and was pressing on the supramarginal and angular convolutions. The man made a good recovery. This case is cited especially as an indication of how a minute, painstaking investigation of the history of an injury and its sequels may prove to be of the greatest value in locating, and therefore in relieving, the disorder. The number of cases of insanity after injury is very considerable, and operation is certainly justifiable in such cases if in any, provided there be reasonable indications not only of an injury, but also of such connection between the injury and the insanity as would show that the injury stood in a causal relation to the mental disturbance. It would be folly, for instance, to trephine for an injury received after the insanity began unless there were independent reasons for doing so, such as paralysis, etc., as a direct result of the injury. Mr. Claye Shaw has recently trephined also in cases of general

paralysis of the insane, but the number of cases is too small and the time since the operations too brief to give any data for an opinion whether the operation is wise and will do any good.

III. Arrested Development.—If the cause of the arrest of development be traumatic, something may be done with a hope of relief, as in a remarkable case of Dr. Felkin and Mr. Hare in which a girl of seventeen had sustained fracture of the skull at the age of ten months, followed by paralysis and imperfect development of the right arm and leg. A cyst was found two inches in depth, with an osteophyte half an inch long. This existed outside the dura, which was not opened. The operation was followed by marked improvement.

Where, however, the arrest of development is congenital, the cause has undoubtedly arisen during intra-uterine life, and there is serious doubt whether any good will follow operation in such cases. As has already been indicated under the head of Microcephalus, it is possible that a certain number of cases of general arrest of development of the brain itself in size may be benefited by a linear craniotomy. As a rule, however, in cases of arrested development of intra-uterine origin, with the exception perhaps of microcephalus, it is undoubtedly wiser not to operate, as operation simply exposes the patient to danger without any reasonable hope of improvement.

CHAPTER II.

SURGERY OF THE SPINE.

THE general **anatomical considerations** in relation to the spine which influence the diagnosis and treatment of its various diseases and injuries may be briefly summarized as follows:

It supports the weight of the head, connects the bones of the thorax with those of the pelvis, forms a bony canal for the reception of the spinal cord, gives a basis of support and attachment for the ribs, and, owing partly to its curves and partly to the fact that it is made up of so large a number of bones with the intervertebral disks interposed between them, it lessens in a very remarkable manner the effects of shock transmitted to it from various parts of the body.

The normal curves of the column are three in number, and are all antero-posterior. In the cervical region the normal curve is convex in front; in the dorsal, the convexity is posterior; in the lumbar, the convexity is again anterior. These curves are maintained largely by the varying thicknesses of the intervertebral disks and partly by the differences in the vertical thicknesses of the bodies of the vertebræ.

On each side of the spine are powerful muscles which run longitudinally, the tendons of which are inserted into the processes of the vertebræ. These muscles maintain the body in an erect position, and when in a condition of health preserve the vertical position of the spine by preventing it from inclining to one side or the other. The spinal cord, which is usually about seventeen or eighteen inches in length, does not fill the spinal canal, but is separated from the walls of the latter first by its investing membranes, and then by some loose connective tissue containing a plexus of large veins. It extends in the adult from the upper border of the first cervical vertebra to the

lower border of the first lumbar vertebra, where it ends as a slender prolongation of gray substance extending into the filum terminale.

The membranes of the cord consist of the pia mater, or vascular membrane closely embracing the surface of the cord itself, the arachnoid, separated from the pia mater by an interval known as the subarachnoid space, and the outermost membrane, the dura mater, separated from the arachnoid by an interval known as the subdural space. The arachnoid and dura mater are here and there connected by areolar tissue, but for the most part are simply in contact, the cerebrospinal fluid keeping the arachnoid in close relation to the under surface of the dura. The cord is steadied in the spinal canal largely by means of the nerves which find exit through the intervertebral foramina on each side of the spinal column. The anterior or motor roots are the smaller of the two; the posterior roots, which are sensory, are composed of finer filaments, and each root bears a ganglion which is situated in the intervertebral foramen just external to the point where the nerve perforates the dura. The roots of the spinal nerves on leaving the cord do not pass out directly at the same level, but run obliquely downward, so that the point at which a particular nerve emerges from the cord is considerably higher than the point at which it emerges from the spinal column, this difference of level increasing from above downward. For example, the eighth dorsal nerve emerges from the spinal *cord* opposite the seventh dorsal vertebra, but from the spinal *column* between the eighth and ninth dorsal vertebræ. These anatomical and physiological facts will serve to make somewhat clearer the descriptions of the various diseases and injuries of the spine and of spinal operations.

CONGENITAL DEFORMITIES.

SPINA BIFIDA.—The chief congenital deformity associated with the spine is due to an arrest of development, owing to which the symmetrical halves of the spinal column fail to unite, leaving a more or less considerable space between them. The gap may extend completely through the bodies of the vertebræ, or may be limited to the arches and the spinous processes; the latter is the more common. The lumbar portion is the part chiefly affected, 50 per cent. of all cases occurring in this region, 12 per cent. in the lumbo-sacral, and 27 per cent. in the sacral. As the result of this deficiency the membranes of the cord are pressed through the opening, forming a tumor known as *spina bifida* (Fig. 219), on account of the condition

FIG. 219.



Spina Bifida (original).

of the spine which gives rise to the deformity, and as **hydorrhachis**, on account of the fluid contained in this tumor. The latter varies in size from that of a walnut or of a closed fist to that of a child's head. It is sometimes covered with skin normal in color and appearance, but oftener the skin is thin and translucent, or it may be entirely absent, in which case the tumor will have a raw, florid appearance. The true sac of the tumor consists of the membranes of the cord blended together and enclosing a liquid which is ordinarily the cerebro-spinal fluid. It usually communicates directly with the brain, as in the normal condition, through the opening in the pia mater at the lower border of the fourth ventricle. Pressure on a tumor of this variety will therefore sometimes cause stupor by increasing the pressure upon the brain. The cord is variously situated as regards the sac, being sometimes in front, sometimes behind, and sometimes spread out as a thin layer upon its internal surface. When the protrusion consists only of membranes and fluid, it is called a **spinal meningocele**; when it contains a portion of the cord also, it is called a **meningo-myelocoele**. When the central canal of the spinal cord is dilated, forming the cavity of the sac, the tumor is called a **syringo-myelocoele** or **syringo-myelia**. The second of these is by far the more common.

The **diagnosis** of this condition may be made by observing the following points: 1. The tumor is congenital. 2. It occupies a central position, a peculiarity which characterizes most tumors of intraspinal origin. 3. It may probably be reduced by gentle pressure, or at least greatly diminished in size, the diminution being attended with increased tension of the fontanelle, and sometimes with stupor, convulsions, or other nervous symptoms. 4. The bony margin of the gap in the spine can often be felt at the base of the tumor. 5. The tumor becomes more tense when the child cries or coughs. 6. It is often translucent, and when so an opaque band or bands, consisting of the spinal cord and nerves, may sometimes be seen upon the inner surface of its wall. 7. It is apt to be associated with other deformities, such as hydrocephalus or talipes, or with paraplegia, vesical or rectal paralysis, etc. 8. The cutaneous covering of the tumor is often absent.

Occasionally some of these symptoms may exist and not others. We may have a congenital tumor situated over the middle of the spine, fluctuating and with thin and translucent walls, but not perceptibly affected by the coughing or crying or straining of the patient, and not associated with hydrocephalus or club-foot or paraplegia. In this case the tumor is probably a meningocele, in which the communication with the spinal canal has been shut off. The usual course of such cases is toward death, which commonly occurs within six or eight months; spontaneous cure occasionally, but rarely, happens, the vertebral arches growing and developing, and the neck of the sac correspondingly contracting, and finally becoming shut off from its communication with the canal. Oftener, however, the integuments and membranes over the tumor ulcerate, the contents of the sac escape, and frequently the child dies in convulsions or will perish soon afterward from a septic meningitis following infection through the ulcerated tract.

Treatment.—If the tumor is small, covered with sound skin, and not growing rapidly, it should be enveloped in raw cotton and supported by a very loosely-fitting elastic bandage; or gutta-percha may be used as a binder; or a layer of cotton brushed over with collodion may be applied to its surface. There is a chance by this method that the tumor may shrink and disappear. The outlook is seldom encouraging, as even in the most favorable cases the child is small, poorly nourished, and, as has been said, is apt to have paralytic complications.

As to operative measures, while various successes have been reported by other methods, such as simple tapping and drainage, and more recently in a limited number of cases by excision of the sac, yet on the whole the method of injection of the sac seems at present to offer the greatest prospect of ultimate recovery with the least immediate danger. The sac being cleaned, a syringe which will hold about 2 drams of an iodo-glycerin solution (iodine, 10 grains; iodide of potassium, 1 dram; glycerin, 1 ounce) is chosen, and a moderately fine trocar. The puncture in the swelling should be made well to one side, obliquely through healthy skin, and not through the membranous sac-wall, the objects being to avoid wounding the cord or nerves and to diminish the risk of leakage of the cerebro-spinal fluid. Unless the sac is very large, it is probably better not to draw off much, if any, of the fluid on the first occasion. The child should be laid upon its side. About a dram is the quantity recommended to be injected. Care must be taken to prevent escape of the cerebro-spinal fluid, because any leakage may lead to septic meningitis and death. When the needle is withdrawn the tissues should be pressed around it and the little aperture immediately painted with collodion and iodoform and covered by a dressing of dry gauze secured with collodion. A little chloroform may be given, to prevent any crying and straining at the time. The child should be kept as quiet as possible afterward, on its side, and an assistant should make sure, for the first hour at least, that no leakage is going on. Shrinking of the cyst, setting in rapidly and continuing steadily, shows that all is well. If the injection fail altogether or cause only partial obliteration of the sac, it should be repeated at intervals of a week or ten days (Jacobson).

A number of successful cases of *excision* have been reported, and recently Bayer has reviewed the whole subject, and rejects the use of the seton, the injection of iodine, and the excision of a part of the sac, as being at the same time unsatisfactory and dangerous. He urges that the condition is one analogous to hernia and should be treated in a somewhat similar manner; that the danger of meningitis in the one case is no greater than the danger of peritonitis in the other; and that, as compared with the operation above mentioned, it is both safer and more radical. In one case he operated in the following manner: Two lateral flaps were made from the skin covering the tumor and were dissected down to its pedicle, and the sac of the meningocele was opened. The cauda equina was seen flattened out on the posterior wall of the sac. It was loosened after dilatation of the incision, and was replaced in the spinal canal. The sac of the meningocele was then removed, leaving only two lateral flaps of the dura, which were sewed together after thorough antiseptic cleansing of the wound. The muscles and skin were afterward brought together separately. The case was successful. Bayer suggests that possibly in the future, through a greater development of the technique of the operation, a bony roof over the sewed sac may be produced by forming two lateral periosteal flaps from the canal of the sacrum.

Hildebrand has collected 87 cases of excision with 23 deaths, a mortality of 26.4 per cent. Unquestionably, operative measures, especially in meningocele, are gaining ground in the estimation of surgeons.

SPINAL TUMORS.

Congenital tumors other than spina bifida are found chiefly in the sacral region, and may be of various kinds. *Lipomata* sometimes here attain a very large size, and occasionally spring from the interior of the spinal canal. *Dermoid cysts*, containing the usual contents, hair, sebaceous matter, etc., are not infrequent, and may communicate with the rectum or the bladder. The

so-called **congenital sacral tumor** is a large mass occurring in the region of the coccyx, sometimes pedunculated and made up of cysts of various sizes, often lined with columnar epithelium and filled with a viscid, gelatinous material. **Fœtal tumors** of all sizes may be found in the same region, and may contain merely masses of the different tissues or a considerable and well-developed portion, a limb or a trunk, of the fœtus incorporated with the individual who bears it.

All these growths may be treated by excision, although, as their extent is often uncertain before operation, great caution should be exercised.

Tumors of the spinal cord itself may be either intra-medullary or extra-medullary, and are of great variety. The diagnosis will usually be made by the neurologist rather than by the surgeon, but it is proper to give a brief outline of the general diagnostic points which it will be necessary to bear in mind before deciding upon or rejecting operative interference. In the first place, it will be requisite to determine whether the symptoms are due to pressure on the cord or to inflammatory or other changes involving primarily the structure of the cord itself. If, in a case of paraplegia, there is the history of a very gradual onset beginning with pain and followed first by motor paralysis and then by sensory paralysis; if the symptoms are irregularly unilateral; if the pain has first seemed to be neuralgic or rheumatic and burning and shooting in character; if the anesthesia and pain in the lower limbs ascend gradually from the soles of the feet toward the trunk; and if at the same time there is a constant dull ache in a distinct segment of the spinal column, accompanied by a feeling of weakness at that point, much heightened by fatigue,—we have a group of symptoms pointing strongly in the direction of a neoplasm. In addition, it would be found that at first the reflexes,¹ both deep and superficial, were much exaggerated, becoming gradually lost as destruction of the cord with descending degeneration and wasting grew more marked, the abolition of the reflexes beginning, as in the case of the pain and anesthesia, in the plantar region and passing gradually upward.

Later in the disease we have the development of spasms with clonus, which are most marked in the intradural cases, as is also the symptom of rigidity. Local nutrition is not usually impaired; tenderness of the spine on percussion when it occurs in the dorsal region appears to be lower than the tumor producing it; in the cervical region this generalization does not seem to hold so closely. The feeling of stiffness and weakness will usually be found to correspond to the position of the tumor. Lateral curvature of the spine is a secondary result of the tonic spasm of the spinal muscles, and therefore the concavity of the bend is on the same side as the growth. The pupils are not affected, except when the cord is pressed upon above the level of the second dorsal nerve.

The age of the patient, judging from Mr. Horsley's tables, throws but little light upon the diagnosis of tumor, as we find lipomata occurring at an average age of two and a half years, sarcomata at eighteen years, echinococcus at thirty-four years, tubercle at thirty-nine years, scirrhus and myxoma at forty-eight and fifty-three years. These figures apply to extradural growths. In the case of intradural growths we have tubercle at eighteen and a half years, myxoma at forty-three years, fibroma at forty-four years, sarcoma at forty-one, psam-

¹ By a "reflex" is meant an involuntary muscular response to certain irritations of the skin (superficial reflex) or of the muscles (deep reflex), or, as it is often called, "tendon-reflex." The commonest example of a superficial reflex is the movement of the leg upon tickling the foot-sole; the best instance of a deep reflex is the "knee jerk," or sudden extension of the leg following a tap on the ligamentum patellæ.

moma at fifty-one years. It will be seen, therefore, that while age may be of use in excluding certain forms of growth, as, for example, tubercle in intradural growths in persons beyond thirty years, it is of but little value in deciding the general question as to the presence or absence of a neoplasm.

This sketch of the principal symptoms makes a tolerably distinct clinical picture, but one which is, nevertheless, liable to great variation, and therefore difficult to differentiate from that of certain conditions of the cord, some of which are due to causes quite beyond the reach of operation. The chief of these are—spinal hemorrhage, extra-medullary or intra-medullary; pachymeningitis externa, from caries; chronic transverse myelitis; primary lateral sclerosis or spastic paraplegia; hypertrophic cervical meningitis.

Having decided in any given case that the symptoms are probably due to tumor, the interesting question, whether it is within or outside the membranes, will still remain to be settled. The best general guide will be found in the fact that the symptoms of intra-medullary growths are chiefly those of motor and sensory impairment, while the extra-medullary growths produce much more markedly irritative effects, as, for example, pain, spasms, etc. In the presence of a paralysis of gradual development, preceded by long-continued signs of nerve-irritation and with a distinct unilateral element, the transference of paralysis from one to the opposite limb having been effected slowly and after a considerable interval, the diagnosis of compression of the cord by some cause outside of its own structure would seem warranted. Aneurysm might be excluded in the absence of the characteristic physical signs and of evidence of erosion of the spinal column; gumma would be accompanied by a history of syphilis, would often be associated with other and recognizable specific lesions, and would possibly yield to the use of iodide of potassium: a new growth (cancer or tubercle) in the bodies of the vertebræ themselves generally causes a perceptible deformity. By attention to the points which have been mentioned a tolerably correct opinion may be arrived at.

Prognosis.—All the evidence which we now have points to extraordinary reparative power on the part of a cord which has simply been suffering from compression, and to an almost equally remarkable tolerance to operative interference. The material for finely differentiated prognosis can hardly yet be said to exist, but in a general way it is safe to say that the diagnosis of tumor (if it be non-malignant) carries with it a reasonably favorable prognosis, which is strengthened if, in addition, the tumor is thought to be extra-medullary.

As a result of these considerations it seems proper that every case of focal spinal lesion thought to depend on a tumor, and not distinctly a malignant and generalized disease, should be regarded as amenable to operative interference, at least of an exploratory character, no matter how marked or how long continued the symptoms of pressure may have been. The operation is practically identical with that of resection of the laminae. (See p. 572.)

NEURALGIA.—In some cases of intractable brachial neuralgia, and in others of spasms with violent neuralgic pains in the region supplied by the lumbar and sacral nerves, intraspinal section of the posterior roots has been performed. The operation has been done in five cases, in two of them with some improvement, in the others without much success. It should certainly for the present be reserved for cases in which it is desired to verify a doubtful diagnosis, or for those in which the pain is so great and so little affected by other treatment as to justify so serious an operation. It may be performed by following the directions for resecting the arches and opening the dura in the manner described on page 572.

SPINAL CURVATURES.

The more common pathological curvatures of the spinal column are three in number: *Scoliosis*, or lateral curvature; *Kyphosis*, or *Excursion*, an antero-posterior curve with the convexity backward; and *Lordosis*, or *Incurvation*, an antero-posterior curvature with the convexity forward.

FIG. 220.



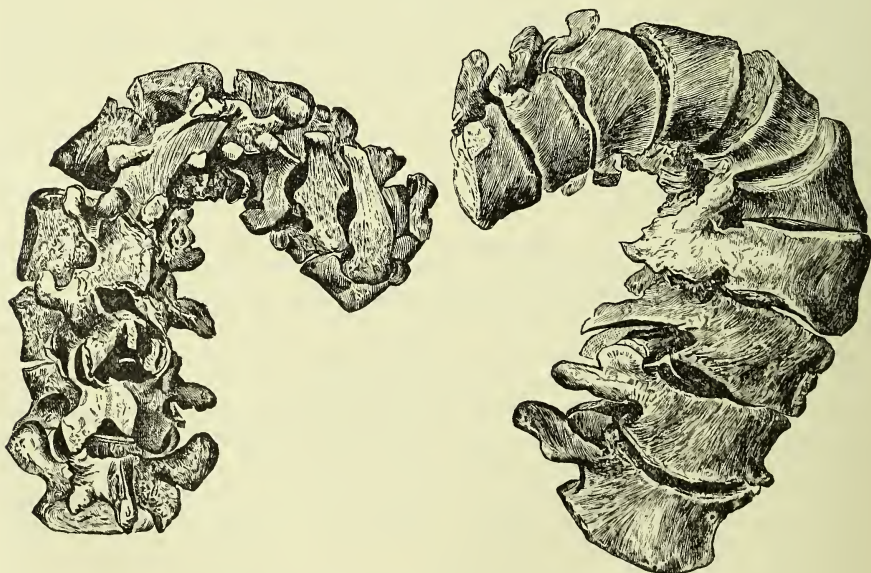
Primary and Secondary
Lateral Curvatures
(Agnew).

LATERAL CURVATURE.—In scoliosis the spine describes two or more lateral curves with their convexities on opposite sides of the longitudinal axis of the back (Fig. 220). The vertebræ of the region involved are also otherwise changed in their relations to the same axis, being rotated so that their spinous processes point toward the concavities of the lateral curves (Pl. XV, Figs. 3 and 4).

Varieties.—The most common curvatures are those in the upper part of the dorsal region with the convexity to the right side. The second or compensatory curve is in the lumbar region with its convexity toward the left (Pl. XV, Figs. 1 and 2). In marked cases a third, also compensatory, may form in the cervical region, and will also have its convexity on the opposite side from the original curve. Occasionally four or five curves may exist, reciprocally compensating one another.

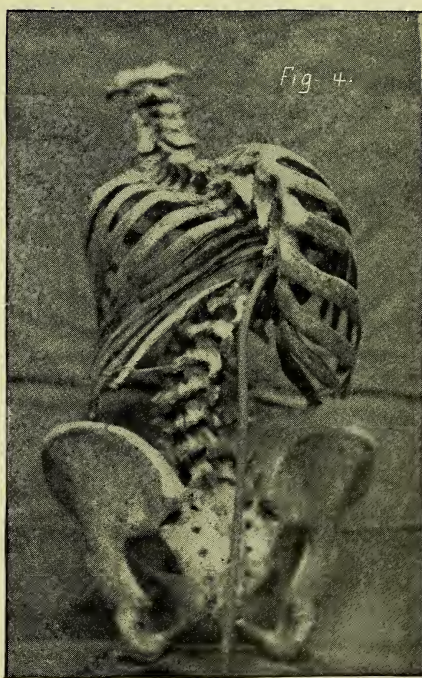
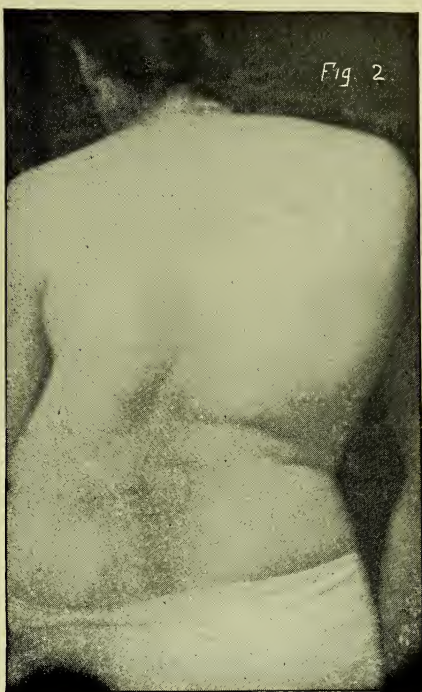
The intervertebral disks in the region of the curve are unequally compressed, becoming wedge-shaped, with the base of the wedge toward the convexity of the curve. The rotation of the bodies of the vertebræ (Fig. 221) is often so extreme that their anterior surfaces point directly toward the convexity and the spines

FIG. 221.



Torsion in Lateral Curvature (Bradford and Lovett).

toward the concavity of the curve. This tends to bring the spines back again into the median line, although sometimes in these cases the twist is so great



Lateral curvature of the spine (scoliosis).

that the angles of the ribs and the transverse processes of the vertebræ occupy exactly the position of the spinous processes.

The ribs on the convex side are widely separated, and are more horizontal than they normally should be; their angles become prominent, and the scapula is carried forward with them, making a large "hump" in the dorsal region. On the concave side the obliquity of the ribs is exaggerated, and in bad cases they may even touch the crest of the ilium. The thorax is therefore generally distorted, and viewed anteriorly will present an abnormal prominence of the left breast (Pl. XV, Figs. 3 and 4).

Causes.—*Predisposing* causes are general weakness, prolonged ill health, rickets, rapid growth, struma, etc. The *exciting* causes are all those conditions which in such a subject produce for long periods an undue inclination of the spine to one side or the other. The typical cases are accordingly seen in delicate girls between twelve and twenty, whose muscular strength and development do not keep pace with their growth, who sit for hours at a desk with no support for their backs, and who carry a heavy weight in the shape of school-books to and from school, and usually on the same side of the body. Any habitual *one-sided position of the body* will have the same effect. Other causes are *obliquity of the pelvis*, produced by unequal length of the lower limbs; *unilateral muscular atrophy* due to central changes when the seat of the trouble is in the spinal cord; *unilateral muscular hypertrophy*, from over-use of one side; or *spasm* from central disease will draw the column toward the side of the enlarged or contracting muscles. *Sacro-iliac* disease, by causing the patient to lean away from the affected side to relieve pressure, *empyema*, through the resulting contraction of the thorax, and *morbid growths* of the sides of the trunk or pelvis, by their weight, may produce the same result.

Symptoms.—The earliest development of this trouble is often insidious. The first complaint of the patient, if a boy, may be that the suspenders on one side slip off his shoulder, or in the case of a girl it may be first noticed by the dressmaker, who may wish to pad out one of her shoulders. Examination will show a slight prominence of one scapula, and perhaps of the opposite iliac crest, and if the spinous processes are followed down the back by one finger with firm pressure, the resulting red line on the skin will show the curve unmistakably.

In severe cases the "hump" on one side, usually the right, the elevation of the right shoulder, the projection of the ilium on the left side, the prominence of the left breast, and the easily recognized curves of the spine, constitute an unmistakable group of symptoms, the majority of which are always present.

In hysterical distortion of the spine the curvatures disappear on making the patient bend forward until the fingers touch the ground. In caries of the vertebræ with lateral instead of antero-posterior curvation the characteristic symptoms of Pott's disease will be present. (See p. 554.)

Treatment.—Perhaps the most important advice to be given to the general practitioner in relation to the treatment of this condition is a caution against the use of braces, corsets, jackets, and other mechanical appliances which, by confining the movements of the chest and supplying an artificial support in place of the muscles which it is most desirable to develop, actually do great harm to many patients instead of good.

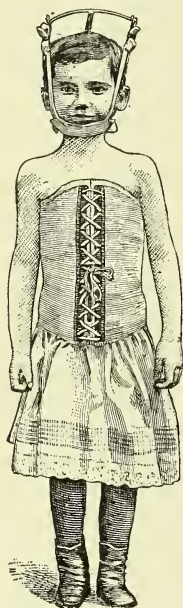
Careful attention to the general health, a rigid observance of all hygienic rules, properly directed exercise both active and passive, and massage, constitute the essentials of the only treatment likely to be of service.

The exercise should be prescribed by the physician. The patient should walk a certain time daily carrying a light weight balanced on the head; should several times daily swing for a few minutes by the hands from a cross-bar; and

should sit on a seat raised some inches on the side corresponding to the convexity of the lumbar curve, so that the spine may be strengthened during the efforts to produce a curve compensatory to the obliquity of the pelvis produced by the slanting seat. A high sole on the shoe on the same side has a similar effect.

The patient should be taught to hold the back in the position in which the surgeon finds the curves to be least perceptible, as in that position the weak muscles must act most vigorously and will gradually be strengthened. A form of exercise which has been advocated by excellent authorities consists in

FIG. 222.



Leather jacket and jury-mast (Sayre).

placing the patient face downward on a table, bringing the shoulders and trunk over the end, and then, while he is held on the table by an assistant who embraces the legs and thighs, causing him alternately to flex and extend the body at the hips while the surgeon or masseur resists his efforts. Massage of the weak muscles, electricity, "muscle-beating," etc. are valuable adjuncts. In very severe and long-standing cases with marked deformity and great weakness, the use of a spinal jacket (Fig. 222), preferably of leather, but it may be of plaster or steel, may be absolutely necessary. Carefully directed gymnastics with the use of special apparatus are often beneficial.

POSTERIOR CURVATURE, OR KYPHOSIS, as a distinct disease, is met with in *infants* as a result of rickets, or of having been nursed in a sitting posture, or encouraged to sit up straight at a very early age: at *puberty* it is usually found in the same class of patients as the subjects of scoliosis, and arises from the same cause; *i. e.* it develops in weakly girls from long continuance in a bad position, such as they often assume in practice on the pianoforte or at a school-desk: in *adults* it may also be caused by employment that necessitates constant stooping over, especially if this is associated with poor food and bad hygienic surroundings. It is accordingly seen in rag-pickers, miners, cobblers, tailors, etc. Oftener it is symptomatic of some other disease, as spondylitis deformans, or is caused by an unconscious effort to relieve certain symptoms, as dyspnea in asthma and emphysema, tenderness in metritis and chronic peritonitis, pain in muscular rheumatism or in chronic rheumatic arthritis.

Pathology.—In the slighter forms of the disease there is merely relaxation of the vertebral ligaments, with separation of the laminæ and spinous processes. In others there is absorption of the anterior portions of the intervertebral disks and of the bodies of the vertebræ.

Diagnosis.—It requires to be diagnosticated only from the deformity of Pott's disease, which may be easily done by noting the absence of muscular rigidity, of pain or tenderness, of abscess, of complications of the spinal cord, etc. The curve of kypnosis is extensive and is a true curve, not an angular projection of one portion of the spine. The disease occurs more frequently in the aged than in children.

Treatment.—It requires to be diagnosticated only from the deformity of Pott's disease, which may be easily done by noting the absence of muscular rigidity, of pain or tenderness, of abscess, of complications of the spinal cord, etc. The curve of kypnosis is extensive and is a true curve, not an angular projection of one portion of the spine. The disease occurs more frequently in the aged than in children.

The **treatment** consists in removing the cause and in developing the weak spinal muscles by appropriate exercise and massage. In young persons abandonment of the vicious posture, with the use of proper exercise, will generally effect a cure. In adults, and especially in the aged, the condition is apt to be permanent, and if very pronounced may require the use of some form of spinal brace.

ANTERIOR CURVATURE, OR LORDOSIS, is often congenital, and may be due to rickets or to disease affecting the posterior portions of the vertebral bodies, but is commonly compensatory and secondary to the deformity of Pott's disease. It may be produced by ankylosis of the hip-joints in partial flexion.

It is usually found in the lumbo-dorsal region, and consists in a marked forward curvation of the lumbar spine, throwing in the loins so that a deep concavity exists in the lumbar region, making the sacrum and the hips prominent, depressing the pubes, and causing a protuberance of the abdomen.

Treatment.—As a rule, it requires no surgical interference, but occasionally, when it depends upon caries of the vertebræ, some artificial appliance will be needed.

SPONDYLITIS DEFORMANS is a term which, though etymologically applicable to an inflammatory disease of the vertebræ producing deformity, such as Pott's disease, is employed clinically to denote chronic rheumatic arthritis of the vertebral column (Treves). It is a disease of old persons, as a rule, though occasionally it is seen in middle life. It is attended with the same changes that characterize arthritis deformans everywhere (see section on Diseases of Joints), and is marked by absorption of the intervertebral disks, by the formation of osteophytes upon the bodies of the vertebræ, and finally by firm bony ankylosis of several vertebræ. The disease begins with pain in the back, followed by rigidity and the development of kyphosis. The curve increases, the ribs become fixed and the thorax immobile, so that respiration is abdominal. When it comes on in middle-aged or elderly persons, and is moderate in extent, it does not seem greatly to influence the expectation of life.

Treatment is of little or no avail, but may be conducted on the general principles applicable to chronic rheumatic arthritis elsewhere.

TUBERCULOSIS OF THE SPINE.

POTT'S DISEASE, SPONDYLITIS.—**Cause.**—Tubercular inflammation of the bodies of the vertebræ is a disease usually found in childhood, affecting more frequently delicate children between the ages of three and ten years, of poor parents, and especially those of tubercular families. No age or class is exempt, however, and occasionally no family history of struma or of tubercle can be elicited. Usually the affection is ascribed to some slight traumatism; this may be the exciting cause in many instances, but the tubercular diathesis or soil is essential to the production of the typical disease.

Pathology.—The inflammation begins in the cancellated structure of the vertebral bodies, which undergoes the changes characteristic of tubercular osteitis elsewhere, the extent and rapidity of the process being proportionate to the number and activity of the bacilli on the one hand and to the vitality of the tissues and of the individual on the other. The results of the rarefying osteitis thus set up may accordingly be threefold: 1. Resolution; 2. Caseation; 3. Liquefaction.

1. When resolution takes place, after a certain stage has been reached, the normal cells get the mastery, the bacilli disappear, the inflammation slowly subsides, the exudation is reabsorbed, and the parts return to their original condition. This result is rare.

2. Far oftener the process of disintegration and caseation advances, the body of the vertebra breaks down, usually at the anterior border first, and masses of fungous granulations replace the osseous cancelli and invade the intervertebral spaces, causing absorption of the disks. Even at this stage, however, repair may begin; ankylosis may follow the transformation of the granulations into

sound fibrous tissue, and a return to health with little or no deformity or functional disability may ensue. This is the result aimed at by the surgeon, and as a rule his successful cases belong to this group.

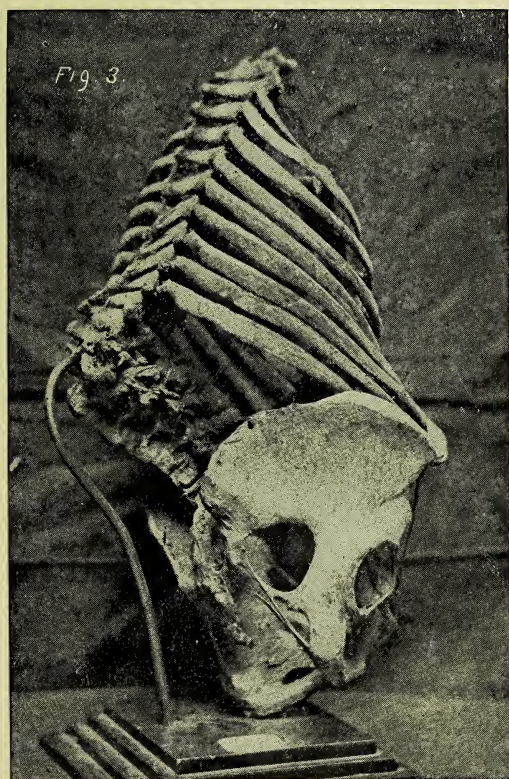
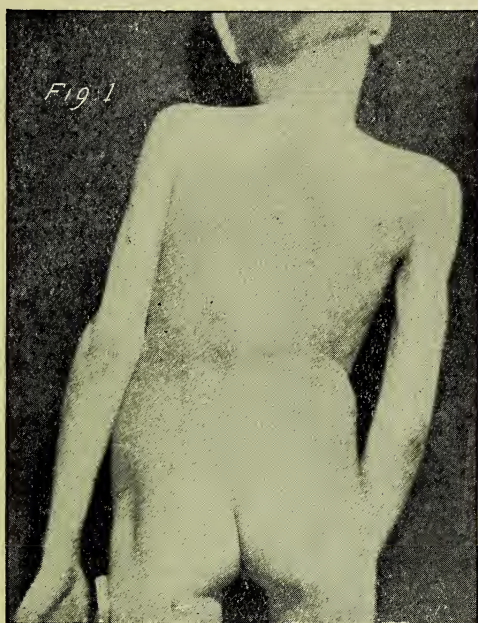
3. In the third class the destructive process is of greater activity: the caseous masses formed in and between the bodies of the vertebræ liquefy and become collections of so-called "tubercular pus;" the anterior surfaces and adjoining edges of the affected vertebræ disappear, as do the intervertebral disks; the whole vertebral body may be absorbed, or more rarely may practically become converted into a large sequestrum lying in a caseous abscess filled with a serous exudation mixed with minute particles of bone, necrotic fragments of connective tissue, and cheesy débris, which together give its contents a milky appearance.

Still later, this collection of fluid finds its way toward the surface by one of several channels and becomes a so-called *spinal abscess*, often, if it breaks spontaneously or is opened carelessly, undergoing infection with pyogenic germs or with germs of putrefaction or with both. During this time the disappearance of the bodies of the diseased vertebræ, permitting the undue approximation of those above and below them, has caused a change in the shape of the spinal column, a falling forward of the segment above the diseased area, a backward projection of the spinous process of the vertebra nearest the area of disease, and the formation of a distinct prominence, which is known by the unscientific name of "angular curvature" (Pl. XVI). This most commonly occurs in the dorsal region. A compensatory *lordosis* often follows in the lumbo-dorsal region. This occurs, though very rarely, as a primary deformity resulting from disease of the posterior portion of the vertebræ. It is, as has been said, more often congenital and hereditary or associated with rickets. Caries in the cervical or lumbar region first causes the disappearance of the normal backward concavities of the spine in these regions, so that straightness of the spine in the neck and in the loins has the same significance as a moderate projection in the dorsal region. During this time a slow thickening of the connective tissue between the dura and the walls of the canal is going on, a so-called external pachymeningitis, which is the chief cause of the paralysis occasionally seen in this disease. This inflammatory growth is oftenest anterior, and by its pressure produces motor paralysis; frequently, however, it is also posterior, and then there is paralysis of both motion and sensation. Occasionally, but rarely, the bodies of the displaced vertebræ impinge upon the cord. Still more rarely there occurs a transverse myelitis of the cord itself. In both these latter cases there would, of course, be paralytic symptoms.

Symptoms of Pott's Disease.—These vary with the stage and extent and situation of the inflammatory process, but observe approximately the following order in their development:

1. The child will complain of *pain* in the region supplied by the nerves arising from the affected segment of the cord. If the disease is lumbar, the pains are abdominal and are apt to be associated with vesical irritability; if dorsal, the pains are epigastric or intercostal, and respiration is sometimes irregular and hurried from the failure of the respiratory muscles to take their full share in the work; if cervical, neuralgic pain or numbness in the arms and hands, a tickling cough, and difficult deglutition are the prominent symptoms. It is to be noted that the pains are apt to be symmetrical.

2. *Increase of pain upon movement*, and especially upon jumping or upon flexing or rotating the spine, is extremely significant. If the child can jump painlessly from a chair to the floor, it is almost certain that no inflammation of the body of a vertebra exists. If the vertebræ be crowded together by

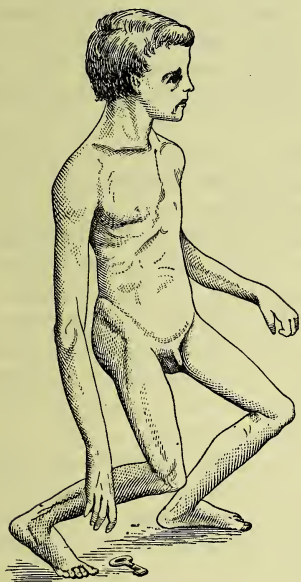


Pott's disease of the spine (spondylitis).

pressure on the head or shoulders while the patient sits or stands or while he lies face downward across the knees of the surgeon, the pain will be much increased. Conversely, if while erect the patient be gently lifted by the hands under the chin and occiput, or if in the prone position on the surgeon's lap the latter's knees be separated so that the spine is elongated, pain will be relieved. Pain may be increased by percussion of the spinous processes, and sometimes the skin over the spinal gutter and the neighboring muscles is tender to the touch; but these signs are of slight value if present, and are by no means constant.

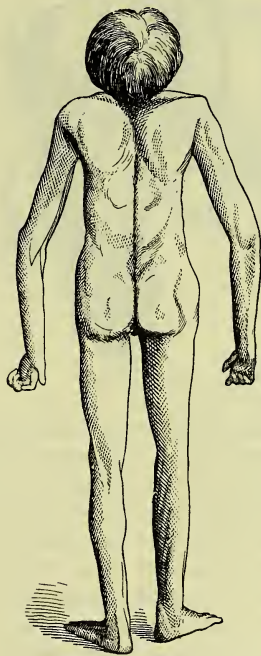
3. *Involuntary immobilization of the spine*, a result of this pain upon movement, is a very characteristic symptom. If the child is asked to look at something behind him, he turns the whole trunk. If he is requested to pick up something from the floor, he stoops by bending the thighs upon the trunk and the knees upon the thighs, never by flexing the spinal column in the usual way (Fig. 223). In walking he moves as though on ice, sliding or shuffling along so as to avoid the jar of successive steps. In standing he fixes the upper portion of the column by the aid of the trapezii and the other scapular muscles,

FIG. 223.



Manner of Picking up an Object in
Pott's Disease (Agnew).

FIG. 224.



Standing Position in Pott's
Disease (Agnew).

the action of which at the same time raises the shoulders and throws the arms out from the side (Fig. 224).

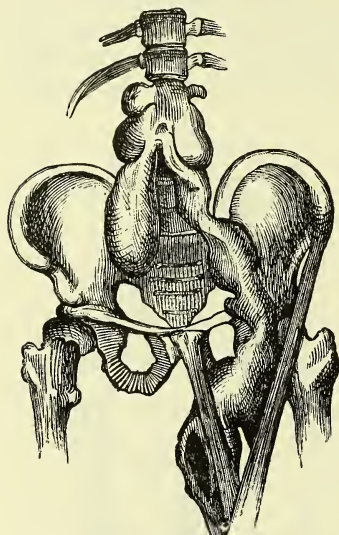
4. In standing or sitting there is also an *involuntary transference of the weight* of the head and shoulders and parts above the diseased area to the pelvis by means of the upper extremities. The hands are often placed upon the hips and the arm muscles are tense. In walking about a room the little patient will support himself upon articles of furniture, going from one to another with great care, losing no opportunity to lay hold of a chair or a couch.

5. The *deformity* will usually be characteristic, and has already been described. As a rule, the diagnosis by means of the above symptoms should be possible before any material change in the contour of the spine occurs.

6. *Spinal abscess* occurs later, and will vary in its position according to the seat of the caries. *a.* In disease of the cervical vertebræ the abscess is apt to be **retro-pharyngeal**. A fluctuating swelling appears in the pharynx, usually to one side of the median line. If it shows externally, it does so behind the angle of the jaw. Sometimes it follows the œsophagus into the mediastinum, or it may pass between the longus colli and scalene muscles and point on the neck in front of or behind the sterno-mastoid.

b. In dorsal caries the fluid collects along the front and sides of the dorsal vertebræ in the posterior mediastinum. Thence it may pass between the trans-

FIG. 225.



Psoas Abscess (Albert).

verse processes to the back, constituting **dorsal abscess**; or may descend to the diaphragm, pass under the outer arcuate ligament, and point in the ilio-costal space as a **lumbar abscess**; or go under the inner arcuate ligament to form a **psoas abscess** (Fig. 225). The latter, being prevented from spreading inward or backward by the spine and the last rib, and having its progress forward checked by the ligament, is impelled downward by gravity and by its increase in size, finding its way most easily into the space between the two origins of the psoas, gradually causing absorption of that muscle, and usually pointing in the groin below Poupart's ligament and to the outer side of the femoral vessels. It may, however, point above Poupart's ligament, on the inside of the thigh, or even below the knee.

c. In lumbar caries the fluid remains outside of the sheath of the ilio-psoas and occupies the iliac fossa, forming an **iliac abscess**, which is apt to occupy the angle at the junction of

the iliac and transversalis fascia and to point on the abdominal wall just above the outer end of Poupart's ligament; or it may gain access to the true iliac space within the sheath of the ilio-psoas, which will then guide it below the ligament to the upper part of the thigh outside the vessels.

As variations from these routes, which are the most frequent, we may have abscesses passing between the ribs to the side of the chest, or opening into the pleura or bronchi, or going through the great sacro-sciatic notch to appear under the gluteal muscles, or through the thyroid foramen to point on the upper and inner part of the thigh.

7. *Paralysis*, always motor at first and often not affecting sensation at all, is the result chiefly of the external pachymeningitis which has been described.

Diagnosis.—The above symptoms will usually enable the disease to be recognized and easily differentiated from thoracic or abdominal aneurysm, hysteria, renal disease, rheumatism and neuralgia, empyema with subdiaphragmatic abscess, etc. The most important symptom in the early stages is, perhaps, the rigidity of the spine; later the deformity is easily recognizable.

Treatment.—The indications for treatment in Pott's disease are, 1. To endeavor to secure resolution of the tuberculous ostitis; 2. To limit the destruction of tissue and the resulting deformity as much as possible; 3. To promote

ankylosis; 4. To evacuate pus; 5. To remove a sequestrum or the focus of carious bone; 6. To relieve the cord from pressure by pus, bone, or, most commonly, by the products of an external pachymeningitis.

The first three may be considered together, and are equally met by the application of the same principles.

Rest is always the most important consideration. In very young children, in patients of all ages where there is very active and progressive disease, and in all cases in which the otitis or caries is situated in the cervical or upper dorsal region, confinement to bed in the *recumbent position* is almost imperative. In cervical caries the head and neck should also be fixed by sand-bags laid one on each side, secured in position by tapes, and extending from the vertex to the shoulder. Extension in bad cases with beginning pressure symptoms may be applied from the chin and occiput, the head of the bed being sufficiently elevated, or from the lower limbs by raising the foot of the bed and applying adhesive strips with weight and pulley, as for fracture of the femur, to both legs; or the two methods may be combined. To prevent excoriation of the skin by the adhesive strips, the legs may first be bandaged and the plasters applied over the bandages.

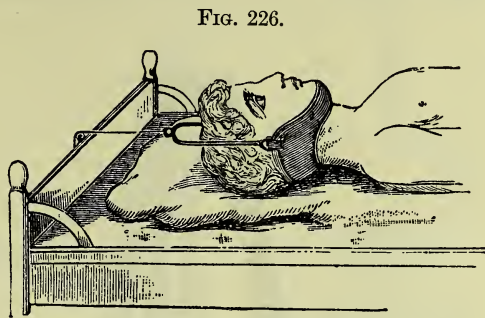


FIG. 226.

Extension in the Recumbent Position (Reeves).

Whenever the patient's circumstances make it practicable and the general health can at the same time be maintained, recumbency with limitation of all but slight and necessary movements should be continued until all symptoms have disappeared, or, if the disease has already reached the stage of caseation or liquefaction, until complete consolidation has taken place.

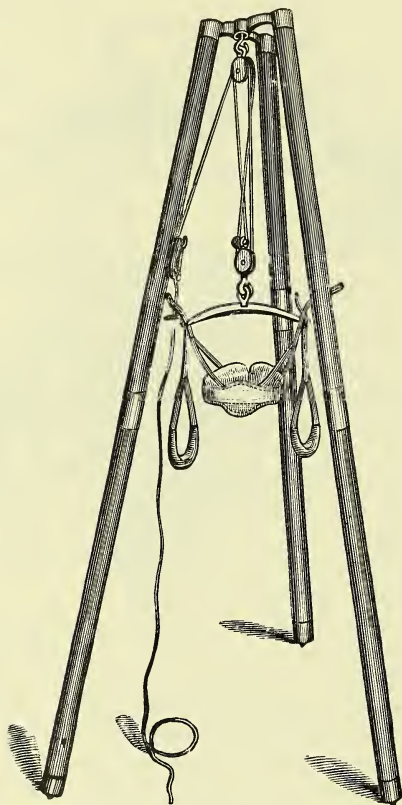
This is not always possible, nor will the child always bear such prolonged confinement to bed. It is, however, so valuable as a method of treatment that every effort should be made to secure its thorough trial. The bed should be wheeled into the sunlight, or, at the proper seasons of the year, into the open air. There should be gentle massage and frictions of the limbs and of the abdominal and pectoral muscles. Alcohol baths, and sometimes in very young children inunctions with cod-liver oil, are useful. The food should be nutritious and as abundant as digestion and assimilation will permit. Much of the success of treatment will depend upon the care and judgment shown in the feeding, and the surgeon cannot too closely scrutinize the details of diet. A large variety of tonics have been employed in these cases, but three are to be especially recommended: viz. a well-made and digestible emulsion of cod-liver oil; the phosphates, which may often be contained in the same emulsion; and iodide of iron in doses to suit the age and the stomach of the patient.

When consolidation has occurred, which will be after a period represented by months rather than weeks, and is accompanied by a disappearance of symptoms and an increase in the general strength and well-being, the patient should be allowed to sit up, cautiously at first, and if the deformity has been marked should wear some light form of spinal jacket. The higher the caries in the vertebral column, the greater should be the caution in permitting the erect position.

Rest of the affected region when the disease is below the mid-dorsal vertebræ and is not too acute or extensive, and where the patient is old enough, may be satisfactorily obtained by the use of some form of spinal jacket, by means of which the weight of the parts above the disease may be transferred from the spinal column to the curves and bony prominences of the pelvis and hips.

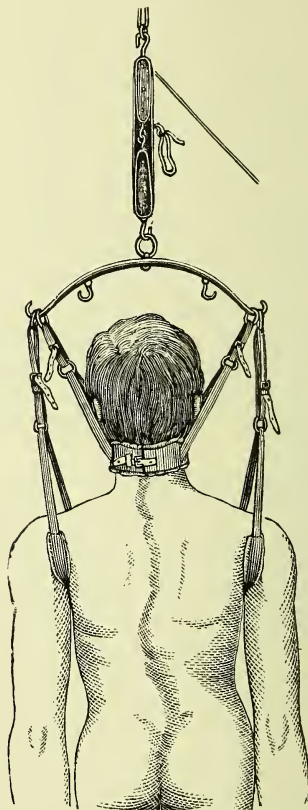
The simplest of these jackets is that known by the name of Dr. Sayre, who devised it. It may be applied as follows: The patient is stripped, and a closely-fitting woollen undershirt, reaching below the nates and provided with shoulder-straps, is put on. He is then placed beneath a tripod, and a leather headgear

FIG. 227.



Tripod for the suspension of the patient
(Sayre).

FIG. 228.



Patient in position for the application
of the plaster jacket (Sayre).

embracing the occiput and chin is adjusted, and in older children or adults axillary bands are added (Figs. 227, 228).

By means of pulleys the patient is then elevated (*a*) so that the toes just touch the floor; (*b*) or so that the heels are about two inches from the ground, the "fore-pads" of the feet being in contact with the floor; (*c*) or so that the heels are merely raised from the ground. These various degrees of extension are to be applied according to the age and weight of the patient and the extent of the disease, the first mentioned being suitable for the youngest and lightest children and the least extensive disease, the last applying to adults and to more severe forms of the trouble.

While the patient is held in this position the woollen shirt is kept drawn well down, pads of cotton wool are applied over the iliac spines and other bony

prominences, the space between the breasts in women is filled with a temporary pad, and a wedge-shaped pad is placed over the lower part of the abdomen under the shirt, with the base of the wedge upward, enclosed in a towel to admit of its ready removal. This is the so-called "dinner-pad," intended to leave a space after its withdrawal which will allow for the physiological distention of the abdomen after eating. Plaster bandages are then applied, rollers $2\frac{1}{2}$ to 3 inches in width and 6 yards in length being used. The first turns are made midway between the trochanter and the crest of the ilium, and they are then carried regularly and smoothly up to the axilla, each turn overlapping the preceding turn about one-third (Fig. 229). About three layers are required. An assistant with a basin of dry plaster and a wet sponge may strengthen the dressing here and there if required, and can keep it smooth. The jacket should be left on until the plaster has set, usually about fifteen or twenty minutes, and the patient should then be taken under the arms and carefully laid upon a hard mattress, where he should remain about an hour. He may then be allowed to dress and go about. The temporary pads should be removed.

If the jacket has been well applied it will usually give relief or comfort. It should never be worn continuously longer than ten or twelve weeks. When removed, the parts can be inspected and abrasions or excoriations treated while the patient is recumbent. A new jacket may then be put on in the same manner as before. The advantages of the plaster jacket are its cheapness and the readiness with which it can be applied. Its disadvantages are its weight, its liability to exert uneven pressure, and its concealment of the parts beneath it for so long a time. Some of these may be removed by cutting it down the front after it has hardened, springing it off the patient, and making holes at a short distance from its two edges, after "binding" them with a broad strip of adhesive plaster, so that it may be laced. It should not be used in very young children, in early and acute disease, in the presence of cardiac or pulmonary complications, over abscess which is pointing, or in extremely feeble and anemic patients. In all these cases recumbency, with proper attention to diet and hygiene, is preferable. A jacket of half-tanned leather (Fig. 222), such as has been recommended by Agnew, can be made by a good surgical cutler from a mould taken in plaster as just described, and is much lighter and more comfortable. A jacket of poro-plastic felt is also recommended, and can be readily applied. Corsets of various sizes are made of this material. The patient is suspended, wet cloths are wrapped around the body, and a corset of the proper dimensions is momentarily dipped in scalding water and is then moulded to the figure. After it "sets," it can be made to lace down the front, and is easily removed and reapplied.

In cases of disease above the mid-dorsal region the "jury-mast" (Fig. 222)

FIG. 229.



Plaster applied, and slit up in order to prepare plaster cast.

must be applied in addition. It consists of a vertical bar fitted to the curve of the back and neck, extending above the head, and carrying the occipito-mental leather apparatus. The jury-mast removes injurious pressure on the softened vertebral bodies by supporting the weight of the head and of the portion of the trunk above the diseased vertebræ on the chin and occiput. The lower end of the bar is held in the plaster by a cross-piece or is riveted to the poro-plastic or leather jacket. In cases where the jury-mast is thought unsafe, a breast-plate and collar for the same cases have been made by Edmund Owen; but such cases are far better treated by recumbency.

The Treatment of Spinal Abscesses varies somewhat with their situation, but the rule should be to open them freely as soon as they are accessible. Aspiration is usually a failure. Tapping and irrigation with antiseptic fluids, or the injection of an emulsion of iodoform, or the swabbing out of the cavity, followed by the use of iodoform and the treatment of the cavity as a simple wound, have all been tried with more or less success. The results from any of them are vastly better than were obtained by any of the older methods, but their precise comparative value is as yet uncertain.

Retro-pharyngeal abscess if pointing in the pharynx should be opened promptly, to avoid the danger of suffocation which attends its spontaneous and unexpected evacuation. Of late, the tendency of surgeons is toward reaching these abscesses by external incision, instead of through the mouth, in order to secure asepsis. The incision is made at either border of the sterno-cleido-mastoid muscle and the abscess reached by a careful dissection, especially in the neighborhood of the vessels.

Psoas abscess may be opened either in the loin or in the groin or in both localities. If only one is selected, the former is beyond all doubt to be preferred. A vertical incision at the outer edge of the erector spinæ should be carried down through the external oblique, internal oblique, and transversalis muscles and the lumbar fascia until the edge of the quadratus lumborum is seen. Then a transverse division of the fibers of that muscle and of the transversalis fascia on the level of the tip of the second or third lumbar transverse process avoids the lumbar arteries, which are above and below the process, and gives access to the finger, which in lumbar abscess will go at once into the abscess-cavity, and in psoas abscess will easily pass through the attenuated sheath and the few remaining fibers of the psoas into the collection of pus (Trevé).

A second opening made below Poupart's ligament by cutting on the end of a long probe introduced through the loin will permit of through-and-through irrigation by means of a large drainage-tube, which later may be replaced by two tubes, to be gradually shortened so that the abscess-cavity may contract in the middle.

With proper antiseptic precautions the opening of a spinal abscess should not be attended by the development of the hectic fever, the emaciation, and the rapid failure which so commonly followed this operation in earlier days. It was then thought to be due to the removal of the internal pressure of the pus from the vessels in the walls of the "pyogenic membrane," but undoubtedly it was the result of infection of a tubercular cavity with pyogenic organisms.

The lumbar operation is also to be preferred, as enabling us in a certain number of cases to meet another indication—namely, the removal of the focus of carious bone. In so-called "posterior vertebral disease," *i. e.* in cases in which the osseous lesions are localized in the transverse or spinous processes or the laminae, operation is of course both easy and satisfactory, and seven out of eight recorded cases have given excellent results. Posterior vertebral disease is, however, extremely rare. When the bodies of the vertebræ are diseased, as is

usually the case, above the twelfth dorsal they are practically inaccessible, except in very unusual cases associated with extensive caries of the ribs. At and below that point, however, an operation such as the one described above may be of great use. Fourteen such operations have been followed by eight cures, five cases improved, and one death which had no relation to the operation itself. They have shown that the solidity of the spine is not affected by either the curetting or the removal of a sequestrum, and have demonstrated that the costo-iliac space in proper cases (*i. e.* in those where only one or two vertebræ are affected and there is but slight angular projection with a curve of large radius) is ample for the work to be done. For these reasons it is safe to say that the search for the focus of bone disease in caries of the lumbar vertebræ is indicated with sufficient frequency to give the matter a real surgical interest. The seat of disease may be sought in exceptional cases even before the appearance of an abscess, and in the presence of an abscess may often be reached with great ease and certainty. The bodies of the lumbar vertebræ are accessible by Treves's operation even when no abscess which is appreciable clinically is found. If an abscess exists, therefore, even when it points anteriorly it is proper to open it by the lumbar route and seek the focus of disease. This permits us, if the abscess depends on vertebral disease, to reach the twelfth dorsal vertebra without wounding the pleura. The benefit to the patient in successful cases is as definite and unmistakable as that following the removal of a focus of tubercular ostitis and caries in any other region.

The last indication for operative interference, *viz.* the existence of paralysis thought to be due to pressure upon the cord, is to be met in various ways.

It should be clearly recognized that such cases, especially in children, frequently recover under careful hygienic treatment, when the abscess, if any exists, can be evacuated and the treatment by extension and a spinal jacket employed. It has been shown conclusively by Weir Mitchell that no case of Pott's paralysis ought to be considered desperate without the trial of suspension, which has succeeded after the failure of other accepted methods, such as continued rest in bed, with the administration of tonics and frequent cauterization with the hot iron; that the pull probably acts more or less directly on the cord itself, and the gain is not explicable merely by the obvious effects on the bony curve; that the methods of extension to be used in these cases may be various, provided only that we do get active extension; and that the plan and the length of time of extension must be made to conform to the needs, endurance, and sensation of each individual case.

Extension may be employed by making the bed an inclined plane, or more forcibly with the patient in a sitting position. In either case the stretching is done through traction from the chin and occiput by means of a collar resembling that used in swinging the patient for the application of a plaster jacket (Fig. 226). When this form of extension can be borne (and it generally can be) it is very effective. It must be the method used in high dorsal and cervical caries. In other cases the extension may be made either from the upper portion of a spinal jacket applied in the usual way or from both the jacket and the occipito-mental collar. This distributes the pull and renders it a little less severe, although if suspension from the head is done gently and the amount of the pull is increased slowly, very few patients complain of it. If the extension is to be made from a spinal jacket, loops of bandage, like the straps of a girl's dress, should be carried up over the shoulders during its application, their loose ends being imbedded in the plaster. In all cases the extending force is the weight of the patient's body.

The apparatus may be improvised by having the collar made of quilted

canton flannel, the foot of the bed being raised if the use of an inclined plane is indicated, and the cord attached to the cross-bar, or, if vertical suspension is desired, a gallows can be made by a carpenter to straddle the bed and to carry the cord and pulley. The pulley may be fixed at the end of an iron support resembling that used in the "jury-mast" extension for Pott's disease. This may be fastened to the back of a reclining chair, so that it curves out over the head of the patient, who can then, if he is old enough, regulate for himself the amount of pull which he can sustain with comfort. This admits of very delicate graduation of the extending force, by suspending the patient from a spring balance attached to the jury-mast.

This method of treatment should be persevered in for weeks or months if there is the least indication of improvement, and will sometimes produce remarkable results in apparently hopeless cases. Of course the most careful attention to hygiene must be combined with this as with any other form of treatment employed. Electricity and massage to keep up muscular nutrition, good food, iron, and cod-liver oil, pure air and sunlight, are as important as they always are in tubercular disease.

In cases in which all this has been tried unsuccessfully, or in those in which the disease is slowly but steadily progressing to an unfavorable termination, when with more or less complete loss of motion and sensation below the level of the lesion there are incontinence of urine and feces and the development of bed-sores, and especially when acute symptoms threaten life, resection of the arches and laminae of the affected region becomes justifiable.

When the tubercular process affects the arches and there is paraplegia, we may sometimes operate in the hope, not only of freeing the cord, but also of removing at the same time the focus of disease. This double indication may also be fulfilled in those cases in which, without bone disease, there is a posterior pachymeningitis or a tuberculoma occupying the canal. Here again, however, time and careful attention to hygiene, including change to sea- or mountain-air, often work wonders. If the lesion of the bodies of the vertebræ is in the lumbar region at a point where these bodies are accessible, it may be possible in certain cases to expose the cord from the back by removal of the laminae, with the object not only of removing pressure, but also of reaching and taking away the diseased bone and tubercular granulations. In tuberculosis of the body of a vertebra and compression of the cord by *anterior* pachymeningitis we can fulfil only one indication, *i. e.* liberate the cord from pressure. We should operate only in grave cases in which acute compression, the appearance of respiratory complications, and the rapid development of degenerative processes force us to interfere, or in which the course of a chronic case is steadily toward a fatal termination, although no advanced visceral tubercular lesions are present.

Operation having been decided upon for any or all of the above reasons, the prognosis will be favorable in proportion to the youth and strength of the patient, the absence of generalized tuberculosis, and the nearness of the lesion to the base of the spine.

INJURIES OF THE BACK.

SPRAINS.—Sprains of the spine are of all degrees of severity. The structure of the vertebral column is so complex and its relations are so numerous and varied that a great variety of symptoms may follow a sprain according to the extent of the damage which is inflicted. In the mildest degree of sprain the muscles alone are involved, and we then have merely a temporary stiffness and a little local tenderness over a limited area. In more serious accidents, as those occurring during railway collisions, the ligaments may also be involved

and are sometimes actually torn. When this happens in the case of the ligamenta subflava, there may be immediate and severe extradural hemorrhage, followed by temporary paraplegia. The symptoms which are never absent are pain and stiffness. Occasionally there is a little local swelling, but this is not constant. The pain is referred to the extremities of the injured nerves, sometimes shooting down the limbs, occasionally, when the injury is at the lumbodorsal junction, being referred to the pubic region. The skin over the injured part is apt to be exceedingly tender. The stiffness produces a degree of rigidity of the spine which resembles very much that seen in Pott's disease, the patient involuntarily immobilizing the vertebral column and avoiding rotation and flexion as carefully as possible. When the injury is unilateral this muscular rigidity is very marked on the injured side, and is a valuable means of distinguishing real from asserted injury, especially in medico-legal cases, as it cannot be simulated.

The **diagnosis** of severe sprains followed by great helplessness and by some degree of paralysis will sometimes be difficult, as the condition may closely simulate that of fracture. In the latter, however, the paralysis is more absolute, the disability more complete, the tenderness over the spine less diffuse, and there is often an irregularity in the line of the spinous processes which will serve at once to indicate the more serious character of the injury.

Treatment.—This does not differ in its general principles from that of sprains elsewhere. Rest of the part, counter-irritation by dry cups or by some rubefacient, gentle frictions with a liniment containing belladonna, followed later by massage of the affected part, constitute the essentials of treatment. It should always be borne in mind that there may be retention of urine. The use of laxatives is frequently indicated.

The **later symptoms** of spinal sprains are, after all, the most serious and annoying. At the time of the accident there may be the form of general nervous depression which we know as shock, which may even deepen into its graver variety of collapse; or in neurotic patients there may occur the more localized disturbance of cerebral origin known as acute hysteria, but this, as a rule, will disappear within a short time. Later, however, two forms of sequelæ may occur which take a chronic character, and which are classified by Thorburn in his excellent book on this subject as neurasthenic and traumatic hysteria. In the former condition there is a general defect in the nutrition and nerve-power, which when it follows a traumatism is manifested by weakness, loss of memory, mental confusion and irritability, insomnia, headache, eye-strain, photophobia, irregular and frequent pulse, dyspepsia, etc. These symptoms occur in patients who have had mild shock at the time of the accident, and they will generally pass away after rest and tonic treatment. They are very common, and are often associated with those belonging to traumatic hysteria, which Thorburn describes as a functional affection of the nervous system resulting from an injury, due probably to a change localized in some portion of the cerebral cortex, and manifested by well-defined and localized symptoms. He adds that it has no known organic basis, is not reflex in origin, and is neither shock nor neurasthenia. It is an affection of middle life, three times as common in the female as in the male, occurring especially in persons of a neurotic temperament or in those addicted to the excessive use of alcohol. It is favored by great fright or by horrible surroundings at the time of the accident which produces it.

The symptoms may be either psychical, including epileptiform attacks and hysterical insanity; motor, including paralysis and contractures of the limbs and special effects upon such organs as the larynx and the bladder; sensory,

in which case there is anesthesia, hyperesthesia, or paresthesia of the general or special sensory nerves; or lastly, there may be vaso-motor, secretory, or trophic trouble.¹

As to its essential cause, the theory of Charcot, that traumatic hysteria is frequently identical with the conditions produced by suggestion during hypnotic sleep, is the most plausible which has yet been advanced. In lightly hypnotized persons a slight blow on an extremity is often followed by motor and sensory paralyses if these are forcibly suggested by the operator; the same symptoms may follow even without suggestion. The trifling traumatism evokes from the cerebral cortex in its unaltered state the idea of severe injury, and this is promptly followed by the loss of power and sensation which might really follow a genuine injury. In traumatic hysteria the nervous shock replaces the hypnotism, and the abnormal sensation caused by the injury gives rise, as in the above instance, to the "auto-suggestion" which replaces suggestion by the operator.

The **treatment** should consist in isolation, and in endeavoring to obtain control over and influence upon the patient, and should conform to the principles which govern the treatment of neurasthenics by the rest cure.

CONCUSSION as applied to injuries of the spinal cord is a term which may be retained for convenience, but which has no accurate pathological signification. When it is remembered that the cord does not entirely fill the spinal canal, that it is connected with it only at those places where the nerves pass through the intervertebral foramina and by the ligamentum denticulatum, that it is closely embraced by its pia mater, that it is surrounded by fluid, and that the canal and its contents are protected in the most thorough manner imaginable from the effects of violence transmitted through surrounding structures, it is evident that a traumatism which without causing some gross lesion would produce a condition of the cord justifying the use of the term "concussion" must be of rare occurrence. As a matter of fact, it is probable that some actual lesion in the substance of the cord occurs, possibly a rupture of delicate nerve-fibers, possibly a capillary hemorrhage, or, it may be, merely a vaso-motor disturbance with slight serous exudation. In any event, the symptoms are those which attend a moderate degree of shock; that is, a tendency to syncope, pallor of the face, nausea and vomiting, cold perspiration, etc., superadded to which are the special symptoms which arise from the cord, such as numbness or tingling or loss of power in the lower extremities; or hiccough, wry-neck, temporary paralysis of the arms, a sense of constriction of the thorax, or similar symptoms if the upper portion of the cord suffers. The treatment appropriate to sprains of the spine applies to injuries of this character.

CONTUSION of the spinal cord may result from severe sprain, but usually occurs as a consequence of forced flexion of the vertebral column. It is accompanied by hemorrhage into the substance of the cord—*hematomyelia*—which usually occupies the gray substance, and may extend to a considerable distance. It is accompanied by motor and sensory paralysis and a diminution of the reflexes. It may be followed by acute myelitis and all the phenomena attendant upon degeneration or destruction of the substance of the cord. It is obviously difficult to diagnosticate from a fracture in which no deformity exists. The prognosis is, however, more favorable, and in cases of contusion of the cord of moderate severity the improvement which occurs at the end of the first or second week will serve to show the character of the lesion.

¹ For a detailed description of this condition, with illustrative cases, the monograph of Thorburn on the Surgery of the Spinal Cord should be consulted.

WOUNDS of the spinal cord are comparatively rare. From in front the cord is obviously inaccessible, except to injuries otherwise fatal; from behind, the oblique downward direction of the spinous processes serves as a protection. The most exposed region is between the occiput and atlas and the atlas and axis. Of course if the vulnerating body takes an upward direction it may reach the cord in the dorsal region, and in cases of gunshot wound the cord may be wounded by the ball or by fragments of bone, just as in other fractures. As a rule, wounds of the cord are fatal, especially those which are inflicted in the upper segments, and if the wound be in the cervical region above the origin of the phrenics, death will follow almost immediately.

COMPRESSION OF THE SPINAL CORD.—(a) From blood. Spinal hemorrhage may occur as a consequence of injury, and may proceed from the vessels contained in the substance of the medulla or from those between the latter and its membranes, or from the large plexus of veins found in the space between the dura mater and the walls of the spinal canal. The symptoms of *extra-medullary* hemorrhage as given by Gowers, Mills, and others are as follows: 1, sudden and violent pain in the back, more or less diffused; 2, pain along the course of the nerves passing through the membrane near the extravasation; 3, abnormal sensations, tingling, etc., and hyperesthesia, referred to the same parts; 4, spasm involving vertebral and other muscles supplied by affected nerves, and also sometimes the muscles supplied by the cord below the seat of the hemorrhage; 5, general convulsive movements; 6, spasmodic retention of urine; 7, consecutive paralytic symptoms, but not usually complete paralysis.

Some points of differential diagnosis between meningeal hemorrhage and extravasation into the substance of the cord should be borne in mind. Symptoms of irritation, such as pain, hyperesthesia, and spasm, in meningeal hemorrhage usually arise immediately or very early, and may precede paralysis, which is commonly not complete. In hemorrhage into the substance of the cord paralysis may be complete at first or may rapidly become so, and symptoms of irritation may be very largely wanting. Hemorrhage may, and not infrequently does, involve not only the membranes, but also the substance of the cord, giving rise to complex symptoms.

The symptoms of *intra-medullary* hemorrhage are as follows: The onset is sudden; there is a history of traumatism or of disease associated with profound blood-changes; the symptoms are bilateral; there is pain in the back, with disappearance of the reflexes connected with the affected segment; spasms, rigidity, and paralysis come on rapidly, as does also the girdle symptom. Bed-sores, incontinence of feces, and retention of urine develop very early in the case, which runs a rapid course and is often fatal.

The treatment of spinal hemorrhage will depend upon the severity and the persistence of the symptoms. The presence of rapidly-extending paralysis, thought to be due to extra-medullary hemorrhage and threatening life through involvement of important centers, might justify an immediate resort to operation. Persistent paraplegia with the development of bed-sores and the occurrence of cystitis, these symptoms extending over some weeks in a case in which the lesion is believed to have been one of hemorrhage, might also warrant a consideration of the propriety of operation. The prognosis will be the more favorable, either with or without operation, the lower the seat of the compression of the cord. The most favorable cases will be those in which a clot occupies the lowest portion of the canal, pressing upon the lumbar cord or the cauda equina.

(b) Compression from lymph.—Meningitis may result from any one of the forms of injury which have been considered, and may be accompanied by an exudation of inflammatory lymph, which in many cases is sufficient to cause

grave compression symptoms. The most common form of this is the external pachymeningitis of Pott's disease, already described. More rarely a meningitis becomes transformed into a myelitis which involves a certain portion of the cord transversely, and is accompanied by progressive paralysis, pain in the back, the girdle symptom, increased reflexes, ankle clonus, etc.

As to the **diagnosis** of these various forms of injury, the time which elapses between the accident and the development of the symptoms is one of the most important factors. (1) If the symptoms occur instantaneously after a grave injury, the cord has probably been compressed by a displaced vertebra, and the case has been one of fracture or luxation or of the common lesion which combines them both, the so-called fracture-dislocation. (2) If the symptoms have not made their appearance for some time, possibly hours, after the injury, the cause is probably hemorrhage, paralysis not having been produced until a sufficient amount of blood had accumulated to cause the necessary pressure. If the hemorrhage is intra-medullary, less time will elapse than if it occurs between the membranes and the walls of the canal. (3) If the symptoms of paralysis do not appear until a period varying from a week to one or two months, they are probably due to pressure by inflammatory lymph the result of an external pachymeningitis.

FRACTURES OF THE SPINE.

As compared with other fractures, those of the vertebræ are rare, constituting only 3.3 per cent. of nearly 52,000 fractures treated in the London Hospital during thirty-five years. Gurlt's table shows that fractures of the cervical and dorsal vertebræ are almost equally frequent, those of the lumbar vertebræ much less common; that the vertebræ most frequently broken are the fifth and sixth cervical, the last dorsal, and the first lumbar; that is, those which are situated at the junction of the more movable with the more fixed portions of the spinal column. More than one vertebra is usually broken when the injury involves the upper portion of the column. The cervical fractures are by far the most fatal. The great majority of spinal fractures occur during middle life. They are found more frequently in males than in females, probably owing to the greater exposure of the former to injury. The body of the vertebra is the portion fractured in the majority of cases, constituting, according to Gurlt, about two-thirds of all fractures in the cervical region and seven-eighths of all in the dorsal region. Fracture of the arches is found in about one-half of the cases of cervical fracture, one-seventh of those in the dorsal region, and one-eighth of those affecting the lumbar vertebræ. There is reason to believe that the frequency of fracture of the arches has been somewhat under-estimated. Stimson remarks that it does not seem improbable that some of the severe sprains of the lower portion of the back which leave a more or less permanent weakness or sensitiveness of the part may be fractures of the arch without displacement and possibly without union. Certainly when the fracture occurs from direct violence, which is comparatively rare, the arches are especially likely to be broken. In 81 cases of resection of the spine for fracture and luxation White found a record of fracture of the laminæ or arches in no less than 45 per cent. Of course, as he remarks, this does not represent the actual frequency of this form of fracture, as doubtless in many of these cases it was recognized previous to the operation and constituted one of the principal indications therefor. The most common cause of fracture of the spine is forced flexion, the head and neck being bent forward upon the chest, or the thorax upon the pelvis. This occurs commonly in accidents in which embank-



Fracture of the spine.

ments cave in or scaffoldings fall, and probably enters into those forms of fracture in which the patient falls upon the feet or the sacrum or the head from a considerable height. In all these cases we have associated with the fracture, as a rule, tearing of muscles, laceration of ligaments, crushing of the cancellated tissue of the body of the vertebra, hemorrhage into the spinal canal, and commonly some displacement. The portion of the spine above the fracture slips forward and pinches the spinal cord between the arch of the vertebra immediately above and the edge of the body of the broken vertebra (Pl. XVII and Fig. 230). Occasionally a piece of bone is driven into the spinal canal and compresses the cord.

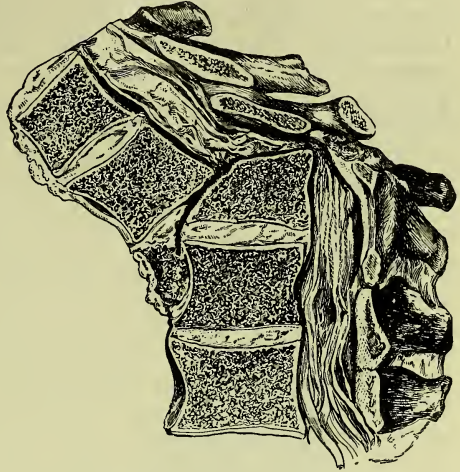
The **symptoms** common to all fractures of the vertebræ are pain, increased on motion, tenderness on pressure, ecchymosis, and more or less extensive paralysis of motion or of sensation or of both. Subsidiary symptoms found in the majority of cases are deviation of the spinous processes and occasionally angular deformity of the spine, phosphatic urine, and disorders of the sexual organs, shown in the male by priapism.

The **prognosis** in all cases is unfavorable both as to recovery of function and as to great prolongation of life, becoming more serious in direct proportion to the higher situation of the fracture, the severity of the injury which causes it, and the amount of crushing or of dislocation.

FRACTURES OF THE LOWER THREE LUMBAR VERTEBRÆ.—These are not very common, and are frequently unattended by serious symptoms. Owing to the fact that the cord terminates at the level of the second lumbar vertebra and that the long roots of the cauda equina surrounded by a firm fibrous membrane slip smoothly one upon the other, and thus slide out of the way of fragments of broken bone, they often escape injury altogether. On account of the lessened rotation in the lumbar portion of the spine and of the large muscular masses that surround the vertebræ there is apt to be no crepitus, deformity, or preternatural mobility, and in the absence of paralysis the only symptoms are local pain and tenderness and a feeling of weakness and instability when the patient attempts to stand. As this, however, would obviously accompany a severe contusion of this region, it is evident that a positive diagnosis is scarcely possible. In exceptional cases paralysis and other symptoms of fracture are present. As a rule, the prognosis is favorable as to life, and, in fact, complete restoration to strength and to functional ability often follows.

FRACTURES BETWEEN THE SECOND LUMBAR AND TENTH DORSAL VERTEBRÆ.—These fractures are followed by paralysis of the portions of the body which receive their nervous supply from the lumbar and sacral plexus. Paralysis of the lower limbs and of the bladder and rectum is exceedingly common. Sensation is sometimes not so completely abolished as motion, but, as a rule, the paralysis of both motion and sensation is absolute. There is at first retention of urine, which as the bladder becomes distended is imperfectly relieved by a slight overflow or dribbling, the so-called “incontinence of reten-

FIG. 230.



Fracture of Spine, with laceration of the cord (Shaw).

tion." This, in cases which are neglected or in those in which septic instruments are used for catheterism, or, in many cases, in spite of the greatest care, is followed by a violent cystitis, with phosphatic and ammoniacal urine. The retention of feces which at first occurs is due to a paralysis of the muscular walls of the intestine; as these gradually recover their power to some slight extent, the contents of the bowels are passed on toward the lower intestine, and, owing to the paralysis of the sphincter, escape involuntarily. When the motions are solid, this takes place at long intervals; when they are liquid, they flow away continuously, the patient having neither control nor knowledge of their escape. The nutrition of the paralyzed parts is feeble; the skin becomes coarse and branny and covered with desiccated epidermic scales. The muscles waste, points exposed to pressure become red or purplish, and unless the greatest care is exercised gangrene follows, producing bed-sores which tend to extend, rapidly involving in such cases the entire thickness of the soft tissues down to the bone and spreading in every direction.

The **prognosis** in these cases is distinctly unfavorable, although some undoubted instances of recovery have been recorded. Life is usually prolonged for from six months to two years. The patients die finally from exhaustion or from the septic effects of the bed-sores or the cystitis.

FRACTURES OF THE DORSAL VERTEBRÆ.—In fractures between the tenth and second dorsal vertebræ there are all the above-mentioned symptoms, with the addition of marked paralysis of the abdominal muscles, distention of the intestines with gas, giving rise to tympany, and difficulty in respiration, which will be greater the higher the position of the fracture, owing to the involvement of a progressively larger number of the intercostal muscles. In addition to the causes of death already mentioned, such patients may die from hypostatic congestion, or from pneumonia which gradually follows the plugging up of the air-vesicles and the bronchi with mucus, which the patient is unable to dislodge by coughing or expectoration. The expectation of life is distinctly less than in the dorso-lumbar fractures.

FRACTURES IN THE CERVICO-DORSAL AND CERVICAL REGIONS.—There is in these fractures, of course, paralysis of sensation at a much higher level than in those already considered. A want of symmetry in the sensory paralysis is often observed at first, but disappears as degenerative changes occur in the cord. Occasionally there is a hyperæsthetic area immediately above the upper limit of anesthesia, due probably to the congestion and irritation of the region just above the seat of injury. If the fracture involves only the first or the second dorsal, but one cord of the brachial plexus will be involved and the paralysis of the upper extremities will be incomplete. If, however, it runs through the lower cervical vertebra, there is likely to be absolute motor and sensory paralysis of both arms. It is important to remember that the seat of the compression of the cord will in the great majority of cases be higher than that of the anesthesia or paralysis by the length of the course of the nerves involved within the spinal canal, and that it will usually be caused by the forward luxation of the vertebra above the seat of fracture. For example, the nerve which supplies the interosseous muscles and the intrinsic muscles of the hand is the first dorsal. Its root in the spinal cord is, however, on a level with the seventh cervical vertebra. Therefore if, in a case of fracture, we had marked prominence of the spinous process of the first dorsal vertebra, we would understand that the cord was probably injured by the dislocation forward of the vertebra immediately above it, and that the highest level of the paralysis which would follow would be indicated by the distribution of the first dorsal nerve.

Thorburn's tables, which are probably approximately correct, but require confirmation, give the distribution of the most important nerves as follows:

Fourth cervical nerve	supplies	the	supra- and infraspinatus.
Fifth	"	"	" biceps, brachialis anticus, deltoid, and supinators.
Sixth	"	"	" subscapularis (this appears to be the highest), pronators, teres major, latissimus dorsi, triceps, pectoralis major.
Seventh	"	"	" extensors of the wrist.
Eighth	"	"	" flexors of the wrist.
First dorsal	"	"	" interossei and intrinsic muscles of the hand.

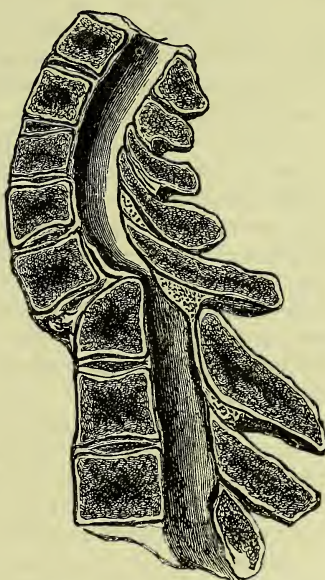
This is very well illustrated by one of Thorburn's cases, in which there was a fracture-dislocation of the seventh cervical and first dorsal vertebræ, the first dorsal having been fractured while the seventh cervical was displaced forward, carrying with it the fragment of the first dorsal. The cord was compressed at that level, and was softened for a short distance above and below the site of compression, its centre being occupied by an effusion of blood reaching as high as the fifth cervical nerve-roots in the form of a narrow cone (Fig. 231). In this case the injury was at the extreme lower part of the cervical region, and must at first have involved the region of the first dorsal nerve, and probably to some extent that of the eighth cervical. At first there was paralysis only of the intrinsic muscles of the hand and the interosseus, but thereafter from day to day it was possible to watch the extension upward of the myelitis, the motor power failing in the following muscles in the order named: (1) flexors of the wrist; (2) extensors of the wrist; (3) triceps and pectoralis major; (4) latissimus dorsi; (5) teres major and subscapularis; (6) deltoids, flexors of the elbow, supra- and infraspinati.

In the majority of cases of fracture of the spine in which life is prolonged for any time a similar series of phenomena will be observed.

FRACTURE OF THE ATLAS AND AXIS.—In fractures above the fourth cervical vertebra when the cord sustains damage the injury is either immediately fatal, or more often the patients survive for a period of time varying from a few hours to two weeks. In one case (Hilton) the patient lived fourteen years, and in another (Shaw) for fifteen months. Fractures of the upper two cervical vertebræ, however, are especially dangerous, on account of the close relations between these vertebræ and the medulla oblongata, and also from their position above the roots of the phrenic nerves and of the nerves supplying the external muscles of respiration.

The symptoms of fracture are complete paralysis of all the parts below the seat of the fracture, rigidity of the neck, pain in the neck or occiput, and sometimes distinct crepitus. These symptoms, however, result also from dislocation, and a differential diagnosis is frequently impossible. The axis is more frequently broken than the atlas, and the odontoid process is sometimes broken alone. The structure of the body of the axis is more spongy than that

FIG. 231.



Fracture-dislocation of the Seventh Cervical and First Dorsal Vertebræ (Thorburn).

of the atlas, and its weakest point is about one centimeter below the neck of the process, which explains the seat of one of the most common fractures. In cases of fracture of the odontoid process with accompanying dislocation, the head is rigidly maintained in a fixed position, and in cases of unilateral displacement is turned to the opposite side. There is often an unusual prominence of the larynx, and the posterior wall of the pharynx may be pushed forward by the body of the dislocated vertebra.

The treatment for such an accident should consist in gently straightening the spine and placing the patient in a supine position, with fixation of the head if the fracture involves a cervical vertebra, by applying sand-bags to each side. The character of the bed upon which the patient is placed is of great importance. The water-bed is preferable to any other, but in cases where this cannot be procured an ordinary mattress covered with mackintosh may be employed, and air-cushions and rubber rings may be used to protect the most salient points. The bladder should be emptied every six hours by means of a Nélaton or Mercier catheter, which should be kept scrupulously aseptic. If cystitis occurs in spite of this, it is sometimes useful to wash out the bladder with solutions of boric acid, peroxide of hydrogen, etc. If the constipation which immediately follows the accident is persistent, it is well to give a cathartic. The greatest care must be exercised in cleansing the parts after any dribbling of urine has occurred or after there has been an action of the bowels. The patient should be washed daily and turned gently from side to side, so that the hips, the sacrum, and all portions of the back may be rubbed with alcohol or soap liniment, and afterward anointed with zinc ointment containing enough carbolic or salicylic acid to prevent decomposition of the secretions. The bed must be kept smooth and the drawsheets and other bed-clothing absolutely without wrinkles. If bed-sores form in spite of these precautions, the affected regions must be immediately relieved from all pressure by the use of rubber rings, and the sores themselves cleansed and dressed antiseptically. In this way the greatest amount of comfort may be obtained while carrying out a purely palliative and expectant treatment. It is obvious, however, that the case is being left during this time to the unaided efforts of nature, the results of which in the great majority of cases are, as has been seen, most unsatisfactory. The tendency of modern surgery is toward rather more active interference with these cases, and it is probably safe to say now that in the majority of spinal fractures in which there is recognizable deformity immediate rectification of the abnormal position is thought to be indicated, just as in any other fracture. This in many cases can be done by the usual methods of extension and counter-extension with manipulation. The lower limbs may be gently drawn upon by one assistant, while the head is firmly held in position by another with his hands upon the chin and occiput. The surgeon can often under these circumstances press the displaced bones into position while the patient lies either upon his face or upon his back. If the fracture is high and the abdominal muscles and external respiratory muscles are paralyzed, great care must of course be observed in turning the patient on his face not to interfere with the action of the diaphragm by pressing upward the abdominal contents, as this has been known to cause fatal asphyxia.

If the deformity cannot be relieved in this way, extension on an inclined plane may effect the same purpose, and a fixed dressing can be applied at the same time by slipping beneath the upper portion of the trunk of the patient, as he lies supine upon a mattress, a many-tailed bandage made of stout flannel and then three to six layers of crinoline plaster bandages. The ordinary suspension collar used in Pott's disease should then be applied to the chin and occiput, and

the head of the mattress or of the bed gradually raised so as to use the weight of the patient's body as an extending force, the collar being fastened to the head-piece of the bed or being held very firmly by an assistant. The layers of bandage may then be moistened and brought into position, a strip of ordinary bandage being interposed between their anterior extremities, so that the jacket may be easily opened and removed if it seems desirable. Extension from the shoulders in cases of dorso-lumbar fracture, or from the chin and occiput in cases of fracture at a higher level, may then be cautiously applied daily, or in some cases may even be made permanent during the process of consolidation.

The results in a number of cases in which this method or some modification of it has been adopted are sufficiently encouraging to warrant its trial in a much larger proportion of fractures of the spine than heretofore, ten cases out of sixteen reported by Burrell having been greatly benefited. In many cases, however, no results follow, and of course the method is open to the objections that there are some risks of increasing pressure on the cord in rectifying the deformity, and, further, that it is difficult to avoid unpleasant pressure effects in spinal cases in which a fixed dressing of this sort is used. Remembering, however, the extremely unfavorable outlook in cases of fractures of the spine treated expectantly, it seems worth while to run these or even greater risks if in a fair proportion of cases the patients can be benefited. Of late years resection of portions of the spine has been employed with increasing frequency in those cases in which the expectant treatment or the treatment by extension had obviously failed, and in some cases has been resorted to immediately after the fracture. The observations are now sufficiently numerous to show that even extensive resections of the laminæ do not greatly or permanently weaken the spine, that under antiseptic methods the risk of consecutive inflammation of the cord or membranes is practically very slight, and that danger from hemorrhage or from loss of cerebro-spinal fluid is not to be feared. They also show that it happens not infrequently that the cord is directly compressed by fragments of the laminæ themselves. The operation is therefore one which should no longer be rejected on the sole remaining ground that we cannot be certain in any given case as to the exact amount of damage which has been done to the tissues of the cord. On the contrary, in the light of experience this would seem rather to favor operation than to contraindicate it. White's statistics show that thirty-seven operations for fracture performed during the antiseptic era have resulted in 6 complete recoveries from the operation and injury, 6 recoveries with benefit, 11 recoveries unimproved, and 14 deaths, a mortality of 38 per cent. Those cases in which the lesion occupied the lumbar region, and especially those in which only the cauda equina were involved, were, as might be expected, especially favorable. So, too, those cases in which fractures of the arches or laminæ existed gave on the whole good results, while the prognosis, just as in the expectant treatment, became unfavorable in direct proportion to the severity of the injury and the height of the fracture. It is safe to say, however, that the results of recent operative interference in properly selected cases of fractures of the spine are encouraging, and are likely to lead to the more frequent employment of resection of the posterior arches or laminæ (*a*) in all cases in which depression of those portions, either from fracture or from dislocation, is obvious; (*b*) in some cases in which after fracture rapidly progressive degenerative changes manifest themselves; (*c*) in all cases in which there is compression of the cauda equina from any cause, whether from anterior or posterior fracture or from cicatricial tissue; (*d*) in the presence of characteristic symptoms of spinal hemorrhage, intra- or extra-medullary.

Operation is contraindicated by a history of such severe crushing force as would be likely to cause disorganization of the cord. What will remain in doubt previous to operation will usually be the extent of damage done to the cord and the possibility of its reparative action. As to this, the safest rule is that which has been formulated by Lauenstein—namely, that if after the lapse of six or ten weeks there is incontinence of urine with cystitis or incontinence of feces, and especially if there are also the development and spreading of bed-sores, but little is to be hoped for from the unaided efforts of nature. If, however, these symptoms be absent, and if there be the least improvement in either sensation or motion, it will be proper for the surgeon to delay operative interference still longer.

The operation itself—**laminectomy**—may be done in the following manner: The patient is placed in a prone position, a gentle curve having been given the spine by means of a firm small pillow placed under the lower ribs. A long incision should be made directly down to the tips of the spinous processes, the middle of the incision being opposite the seat of the fracture. The muscles should be freely separated from the sides of the spinous processes and the posterior surfaces of the laminae. The periosteum may be reflected by making an incision through it along the angle between the spinous processes and the laminae, turning up its edge at this point with the help of dissecting forceps, and then scraping the surfaces of the vertebral arches with a curved periosteal elevator. This should be done neatly, so as to leave as little ragged muscular tissue as possible, since this may become necrotic and produce later trouble. Then the periosteum is similarly reflected on the opposite side. Retractors of moderate size, not large or clumsy enough to be in the way, are all that is needed to keep the muscular masses from interfering with the subsequent procedures. This being completed, the hemorrhage should be arrested by hemostatic forceps, by packing hot sponges between the spinous processes and the detached muscular mass, and by ligatures. The next step consists in the division of the spinous processes close to their bases by means of large, strong bone forceps set at an obtuse angle. This adds nothing to the severity of the operation, while it affords much freer exposure of the laminae, which are the next parts to be attacked. They can be expeditiously and safely divided by the rongeur forceps or by a pair of strong bone forceps, either straight or having a large obtuse angle as may be preferred by the operator. The vertebra at the center of the incision or the displaced vertebra should be selected, and the vertebral spaces above and below its laminae should be recognized with the tip of the finger. The laminae should then be cut through by successive short nips of the bone forceps, the line of section being as close to the transverse processes as possible. This gives the greatest exposure of the cord and of the membranes.

The color of the dura should be noted, particularly with the view of determining in cases of traumatism whether it is or is not necessary to open it. If it be dark or purplish from the presence of exuded blood beneath it, or yellowish from the presence of pus, it will, of course, be proper to incise it in order to empty and to explore the subdural space. If it is determined to open it, it may be picked up in the median line and at the middle of the incision with a pair of delicate toothed forceps, nicked with a knife or the scissors, and then divided either upon a director or with a pair of blunt-pointed scissors to any required extent upward and downward. It can be easily and gently retracted to either side, so as to expose the whole posterior surface of the cord to both inspection and palpation, permitting the gentle insertion of the tip of the finger between its inner surface and the lateral aspect of the cord, and permitting

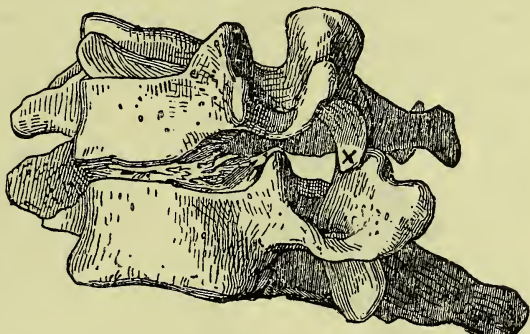
also, if need be, the investigation of the anterior and antero-lateral subdural spaces by means of a blunt curved instrument, such as a pedicle needle or an aneurysm needle. The inspection having been completed, or it having been determined after removal of the cause of compression that no indication for further operation exists, the incision in the dura should be stitched up with fine interrupted catgut sutures. These may be introduced very readily and speedily by means of a pair of staphylorrhaphy or Hagedorn needles, the one not in use being threaded by an assistant while each stitch is being put in place; the stitches should be inserted at intervals of about one-eighth to one-sixth of an inch, and when all are in place can be easily tied, the ends being cut off short. A small rubber drainage-tube and a dozen strands of chromicized catgut should then be laid throughout the entire length of the wound, the muscles being united above them by means of buried chromicized catgut sutures, after which the skin and aponeurosis are brought together by silk or silver wire as may be preferred. It is hardly necessary to say that the most rigid antiseptic precautions should be observed from first to last.

DISLOCATIONS OF THE VERTEBRÆ.

These, as has been said, are commonly associated with fracture, but a number of cases have been reported and verified by post-mortem examination in which uncomplicated dislocation has occurred. They were nearly all of the cervical region. A few dorsal dislocations have been noted, the majority of them affecting the twelfth dorsal vertebra. Only three or four cases of dislocation of the lumbar vertebræ without serious fracture have been recorded and confirmed by autopsy.

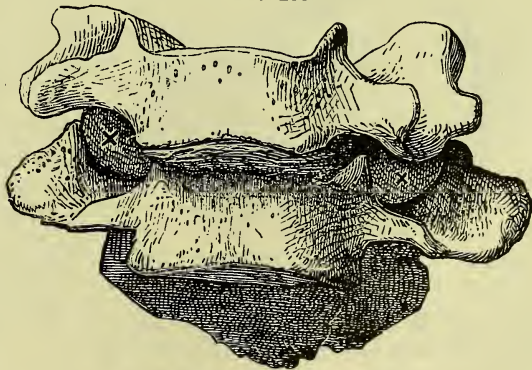
Vertebral dislocation may be caused by forced flexion or extreme extension. When produced by such forces they will uniformly be *bilateral* and either forward or backward (Figs. 232 and 233). They may also be produced by extreme lateral motions of the spine or by excessive rotation. In either of these cases they may be *unilateral*, either forward or backward, and may be *incomplete*, that is, the articular surfaces may remain in contact at their edges; or *complete*, in which case the inferior process of the upper vertebra passes farther forward and sinks into the notch between the body and the superior articular process of the lower vertebra (Fig. 234).

FIG. 232.



Antero-lateral View of a Cervical Dislocation, showing the prominence of the upper vertebra, and at X a displaced articulating process (Koenig).

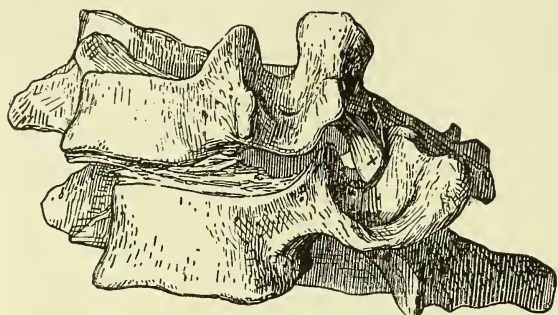
FIG. 233.



Anterior View of Figure 232 (Koenig).

It is usual in treating of dislocations of the vertebræ to speak of the upper one as the vertebra that has been dislocated.

FIG. 234.



Complete Unilateral Dislocation by Rotation or Abduction of a cervical vertebra (Koenig).

cal region it may be possible to recognize the change in the relations of the transverse processes, the body of the dislocated vertebra may be felt through the pharynx, and the absence of the corresponding spinous process may be noted on the back of the neck. The rigidity and the attitude in which the neck is held will often be very suggestive (Fig. 235), but may be closely simulated by the muscular contraction and pain due to contusion of muscles or to inflammation of the intervertebral joints. The paralysis will depend upon the extent of the displacement and the corresponding damage to the cord,

FIG. 235.



Luxation of the Fifth Cervical Vertebra (Blasius).

Of course there are the usual associated lesions, including rupture of ligaments, muscles, and blood-vessels, injuries to nerves, and often laceration of the intervertebral disks. In the absence of deformity the symptoms will be the same as those of fracture of the vertebræ. Crepitus and preternatural mobility are not always obtainable in fracture, and indeed cannot with propriety be sought for in the majority of such cases. In the cervi-

cal region it may be possible to recognize the change in the relations of the transverse processes, the body of the dislocated vertebra may be felt through the pharynx, and the absence of the corresponding spinous process may be noted on the back of the neck. The rigidity and the attitude in which the neck is held will often be very suggestive (Fig. 235), but may be closely simulated by the muscular contraction and pain due to contusion of muscles or to inflammation of the intervertebral joints. The paralysis will depend upon the extent of the displacement and the corresponding damage to the cord, and may vary from a very slight paresis to extensive paraplegia. Usually motor paralysis is more marked and extensive than sensory paralysis, and both kinds are apt to be less absolute in dislocation than in fracture. In some cases of dislocation paralysis has been entirely absent.

Although many surgical authorities have objected to any effort being made to reduce luxation, on the ground that the attempt may cause the immediate death of the patient, especially if the luxation is in the upper cervical region, it yet seems proper in the majority of cases in which dislocation is diagnosed to attempt to replace the part by means of traction aided by flexion or rotation. It is right that the patient and his friends should be informed of the risk of immediate death during this procedure, but the surgeon may conscientiously and urgently advise that

this risk be accepted. The manœuvres will depend upon the seat of the dislocation, but, as a rule, no special method can be indicated. If in a cervical luxation an unnatural prominence in the pharynx can be felt, reduction may be facilitated by making backward pressure with the finger through the mouth while at the same time traction is kept up from the chin and occiput. When

the displacement is unilateral, rotation should be used in addition to extension and counter-extension. The head, which is apt to be inclined to one side, should be carried still farther in that direction, so as to disengage the processes of the luxated vertebra, after which it should be gently rotated and bent toward the opposite side, extension and counter-extension being kept up during the whole of this procedure. In the lower segments of the spine the methods already described for rectifying the deformity in fractures apply equally to luxations. In the majority of cases the operator will be in doubt as to whether or not a fracture coexists.

The **prognosis** is, of course, more favorable in uncomplicated luxations which have been reduced than in fracture, but the injury in all cases must be regarded as a very serious one. Even after reduction paralysis often persists, and death ensues on account of the injury to the cord.

CHAPTER III.

SURGERY OF THE RESPIRATORY ORGANS.

SECTION I.—THE NOSE AND NASAL CAVITIES.

CONGENITAL AND OTHER DEFORMITIES OF THE NOSE.

THE nose varies naturally within wide limits in shape and size, and has been studied alike by the artist and the surgeon, but outside of the natural limits of variation we occasionally see more or less conspicuous deformity. This may be either a failure to develop properly or an unusual width of space between the nasal processes of the upper jaws. A few instances are on record where the nose was totally lacking at birth. On the other hand, a supplementary nose of such size as to cause the individual to be regarded as having a double nose is not unknown. The fissure between the lower lateral cartilages has been known to remain so conspicuous as to cause the individual to display a bifid nose. Failure to develop in length along the dorsal aspect may give rise in a prominent degree to that condition commonly known as snub-nose. That peculiarities in conformation of the nose are particularly likely to be transmitted by heredity is illustrated peculiarly well in the Jewish race. The subjects of inherited syphilis frequently present noses which have little or no bridge or which are so flattened between the orbits as to be unpleasant to regard.

But the most common deformities of the nose or nasal cavities are not those which appear externally or which leave more than a slight external sign, but those which produce variations of contour within the nasal fossæ. Perhaps the most common of these is deviation of the nasal septum, which, though often acquired, is most often of congenital origin. This may be slight in extent or may be so marked as to lead to the virtual occlusion of the nasal passage on one side. Furthermore it frequently happens that the pressure of such a bulging septum against the turbinated bone produces various reflex irritations which are at times quite severe. When the degree of deviation is slight there is but little evidence of it, but when it is extensive there is usually irregularity of external configuration.

The **nostrils** are occasionally contracted from birth, and rarely are completely occluded by more or less tough membrane. When this membranous

occlusion is met with later in childhood, in the majority of instances it will be found to result from cicatricial tissue following ulceration about the anterior nares. Such nostrils may be enlarged by a slow process of dilatation; or a combination of incision and stretching, which latter must extend over a long period of time, may be practised. When the nostrils are completely occluded or obliterated a combination of incision and dilatation is absolutely necessary.

A form of elephantiasis occurs rarely in middle or later life. It has been known to attain enormous proportions. It can be treated only in one way, if at all; that is, by excision of the affected tissue and proper closure of the wound,—if necessary, by some plastic method.

A diseased condition much resembling the above, but due to a very different cause, is that known as **rhinoscleroma**. This is described by Hebra as an affection of the nose, the nostrils, and even the upper lips and the adjoining parts. It is characterized by the appearance of hard swellings or tumors,—in other words, of cutaneous nodosities,—sometimes almost polypoid in shape, isolated or confluent, sometimes of a darker color than the adjoining parts. These nodosities are more or less separated by fissures from which exudes a yellowish fluid. The growths themselves may present cartilaginous hardness. They distort the nostrils and make hideous the nose, and invade even the parts about the mouth. Bacteriological researches of the last few years have shown that they are due to tissue-irritation by a certain specific micro-organism, a bacillus. Stepanow has been able to reproduce the disease in animals by inoculation. It is amenable to but one form of treatment,—that is, free excision during its early stages.

FISSURES OF THE NOSE.—These are almost always connected with defects of development and failures to close at or near the middle line, and are nearly always confined to cases of cleft palate and hare-lip in which the fissure extends up into the nasal fossæ. Their proper consideration and treatment are connected with the surgery of the mouth and face. It has happened once to the writer to see a fissure of the septum, the effect of which was that there appeared to be three nostrils. Under chloroform the thickest portion of this divided septum was cut away and the third nostril abolished.

ASYMMETRY.—Asymmetry of the nasal portion of the face has been studied especially by Zuckerkandl and Allen. While it may be of congenital origin, in the majority of cases it is due to pre-existing stenosis of one nasal fossa, which is thereby deprived of its proper nutrition and does not develop symmetrically with its fellow. This view is corroborated by the result of excluding the entrance of air into one nostril of young animals. A variety of experiments and clinical experiences makes it certain that obstruction of the respiratory canals by enlargement of tonsils, hypertrophy of mucous membrane, and adenoid vegetations in the pharynx occurring early in life is the principal exciting cause of developmental defects in the nose.

SYNECHIA, or adhesion or fusion of parts within the nasal fossæ, is not rare, although those cases in which it is properly of congenital and developmental origin are rare, since it is usually the result of some previously existing ulceration.

DISEASES AND DISPLACEMENTS OF THE SEPTUM.

ABSCCESS.—Abscesses in the septum may be acute or chronic. Acute abscess comprises those forms which follow local traumatism, *i. e.* the purulent transformation of a clot beneath the mucous membrane, as well as those abscesses consecutive to **furuncle**, in the vicinity of a foreign body, or to adjoining ulcera-

tion. Commonly the swelling of the septum can be noticed by inspection through the nostrils. It feels warm and is extremely painful to the touch. Not unfrequently perforation of the septum or loosening of its bony or cartilaginous margins results. When due to spread of septic influences from the neighborhood this affection may be unilateral. The local treatment consists of early and sufficiently free incision.

Chronic abscess is a more progressive and slowly destructive condition, with minor or no inflammatory signs and few if any acute symptoms. It has been mistaken for polyp and for a malignant disease. It is usually either of syphilitic or of tubercular origin. When either of these forms of intranasal disease is primary, it may be followed by erysipelas of the face, by more or less local destruction of tissue, or even by deep phlebitis and meningitis. They are quite likely to be followed by loss of the septum and consequent deformity of the nose.

ACUTE CORYZA.—This is an acute inflammation of the Schneiderian membrane, affecting, at least at first, that portion of it which covers the septum and the lower turbinated bone, and is that condition known to the laity as severe "cold in the head." A similar condition met with in the new-born or in very young infants is a not uncommon sign of inherited syphilis. Except for the distress which it sometimes causes or its reflex effects, it is scarcely of surgical interest, unless it occurs in those who have already some pathological changes in these parts. The influence of cold and wet is predominant in its causation, since a slight chilling of the body is often enough to produce it. It may also be caused by irritating vapors, *e. g.* of bromine, by certain animal or vegetable products, such as pollen, by the odors of certain flowers in susceptible individuals, by various foreign bodies, including polyps, by traumatism, or by eczema or other eruptions within the nose. It may also be attendant upon periostitis, upon furuncle or carbuncle, upon severe conjunctivitis, or it may appear in the course of certain general diseases, like measles, diphtheria, the grippe, etc. In certain individuals it appears so constantly with attacks of asthma as to indicate something more than mere coincidence. The young and those of a tubercular diathesis seem to be more frequently affected.

Its local signs are those of profuse discharge of nasal mucus, with extreme susceptibility and irritability of the Schneiderian membrane, and so much obstructive swelling as to impair or make impossible nasal respiration. A peculiarly uncomfortable and tickling sensation within the nose and a tendency to sneeze on little or no provocation are its most marked symptoms. So tumefied does the mucous membrane become as not merely to prevent that passage of air through the nose which distinct speech requires, but even the quality of the voice is changed. When the disease is severe the frontal and maxillary sinuses are affected by extension, and the pain and discomfort are thereby considerably increased. Often pharyngitis will further complicate the disease, in which case there will probably be more or less implication of the Eustachian tube, with its attendant complaints. In proportion to its severity the sense of smell is impaired or temporarily lost.

An uncomplicated case of this character will ordinarily last five or six days. If anterior and posterior rhinoscopy be practised an excellent demonstration of the cardinal signs of inflammation will be afforded.

Treatment.—Acute coryza is virtually a self-limited disease, but its course may be shortened by local and general treatment. The administration of a brisk cathartic, followed by foot-baths at night, a sedative and antipyretic mixture internally (phenacetin and quinine with small doses of morphia), the

inhalation of steam from boiling water into which a little powdered camphor has been thrown, and the use of antiseptic alkaline spray to which $\frac{1}{2}$ to 1 per cent. of cocaine and 3 to 5 per cent. of antipyrine are added, will be found to give very great relief. A solution of cocaine is often of great value. When the watery discharge is profuse the addition of one-tenth of 1 per cent. of atropine to the spray will materially diminish its excess. If local distress be very great, a triturate may be ordered of 1 part of morphia with 25 parts of bismuth subcarbonate or subnitrate, and the insufflation of a few grains of this will have a happy effect. Avoidance of exposure to draught and cold is of course an important adjunct in the treatment.

OZENA.—This is a term applied to a condition of fetid ulceration commonly due to syphilis or other disease of the Schneiderian membrane, or else to an atrophic form of inflammation of the same commonly known as *atrophic rhinitis*. The ulcerative form gives rise to discharges of a mixed muco-sanguinopurulent character, with expulsion of crusts and scabs, and imparts a most unpleasant and fetid odor to the breath. In the atrophic form of the disease there is little or no ulceration, but so much lack of moisture as to lead to the partial evaporation, decomposition, and drying of what discharge there may be, with more or less disposition to the same characteristic odor of the breath. Some writers include under this term disease of the adjoining sinuses and cellular cavities, which undoubtedly frequently occurs, though not necessarily. Practically, the term is applied to those cases of intranasal disease which give rise to fetor of breath rather than any one distinctive pathological condition.

In every such case careful rhinoscopy should be practised, the **treatment** depending upon the condition found. In most cases before such examination can be satisfactory nasal douches must be repeatedly given, and crusts and hardened masses washed away by means of a spray with a compressed-air force of from ten to fifteen pounds. Not until the nasal cavity has thus been thoroughly cleansed and the immediate congestion caused by this interference subdued, either by waiting a little or by the application of a very weak solution of cocaine, can an exact estimation of the condition be made. In ulcerative forms small, ragged, more or less unhealthy ulcers may be found in almost any part of the cavities, though these occur more commonly in parts most easy of examination. More than this, it often happens that small or relatively large areas of spongy bone will be found necrosed and loose or easy of detachment, or that a necrosed area of cartilaginous or bony septum will be discovered. Patients will sometimes present small portions of bone which have been expelled spontaneously, which will be very suggestive.

Ulcerations in the nose which produce this condition may be of the following varieties: 1, simple, which may have been originally of traumatic origin, due to the finger-nail of the individual, to the presence of some foreign body, or to the effect of some caustic previously applied; 2, tubercular, in which case the general condition of the patient will be extremely significant; 3, syphilitic, where there are almost sure to be other evidences of secondary or tertiary disease, the examiner having probably to look no farther than the mouth of the patient in order to corroborate his diagnosis.

In all these forms of ulceration diseased or dead bone may occur, but this is relatively infrequent in the first. The entire turbinated body, or one or more of the turbinated bones, along with the septum, may be thus destroyed, and even exfoliated externally, and many a sunken bridge of the nose is evidence of the destruction which has gone on beneath, due for the most part to the ravages of tertiary syphilis.

The **treatment** of this variety of ozena consists in the main of removal

of diseased bone, cauterization of the ulcer proper and its conversion into healthy granulating tissue, and such measures as may be appropriately directed toward cleanliness and antisepsis. If necessary, operation may be undertaken, with cocaine or general anesthesia, for removal of sequestra. During the treatment the general condition of the patient should not be neglected, and in syphilitic cases a vigorous antisyphilitic and tonic treatment will effect almost as much benefit as do the measures instituted locally.

In that form of *ozena* due to atrophic rhinitis there is frequently necessity for general and constitutional treatment, while the local treatment is directed first toward cleanliness and freedom from the presence of decomposing crusts, and secondly toward gentle stimulation of the mucous membrane in order to favor healthy secretion. The powders or sprays that are used for this purpose contain substances which are mildly stimulating, such as preparations of benzoin.

PERFORATING ULCER OF THE SEPTUM.—Under this name there has recently been described an ulcerative process occurring usually along the border of the cartilaginous septum, which determines later its perforation, and presents characteristics which apparently entitle it to separate description, inasmuch as it is independent of syphilis, tuberculosis, or lupus. The ulcer is round or oval, and when oval has its long diameter placed antero-posteriorly. The mucous membrane appears to be first affected. Local destruction advances more and more deeply; finally the ulceration thus formed usually tends to general cicatrization about its borders. It appears to attack old men oftener than others. Histologically, the lesion seems to consist of an infiltration with epithelial cells, as well as their subsequent multiplication.

Concerning its intimate cause we are yet ignorant. In some respects it seems to correspond to perforating ulcer of the foot. It calls for little save antiseptic treatment.

DEVIATION OF THE SEPTUM.—Deviations of the nasal septum are very common (Fig. 236), and constitute the most important abnormalities of the nose. Mackenzie, for instance, in examining 2152 individuals, found deviation in 77 per cent., and of a total of 3446 cases examined by several observers there was deviation in about 60 per cent.

Deviation toward the left appears to be more common than toward the right. It varies in amount and character from a simple warping of the septal plate to complete displacement. The causes of the deviation are by no means clear. In the infant the nasal fossæ are small and simple in conformation. The sinuses are not yet formed, and the plates of the ethmoid are still cartilaginous. The cribriform plate is even membranous and continuous with the *falx cerebri* and the *dura mater*, and is thus flexible at a time when the *vomer* is already ossified. At the age of two the frontal and ethmoidal sinuses, as well as the *antrum*, have begun to form. The development of the turbinated bone is also tardy, and relative activity of growth of these parts is a somewhat late manifestation. The posterior or free boundary of the *vomer* is seldom misshapen, since it is thick and strong, but its anterior portion is very liable to displacement, of which traumatism is a frequent cause. Thus it appears that the *vomer*, occupying the middle of a cavity with walls more rigid than itself, frequently

FIG. 236.



Varieties of Deflection of the Nasal Septum (Roberts).

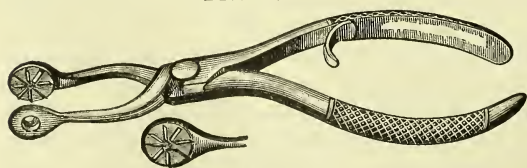
bends in the direction of least resistance, owing to injury or to unequal development of surrounding parts. Deflections of the cartilaginous sections are most common, next those of the bony parts, and finally those of the entire septum. The cartilage may be bent upon itself vertically or horizontally, presenting along the line of deflection a bulging sufficiently prominent to occlude the nares. Horizontal bending is much more common. The deep concavity of the opposite nostril often corresponds with the convexity of the bend. It may cause serious obstruction to the respiration. When the warping is but slight it ordinarily gives rise to no symptoms and calls for no interference. It not unfrequently happens that we have to deal with an enlargement of the middle turbinated bone corresponding with the deflection of the septum, and secondarily with a greater obstruction.

Another form of deformity of the septum is caused by development, near the sutural line of the vomer and the palatal process, of a bony or cartilaginous ridge which constitutes a spur, as it is usually called, and which is in fact an exostosis or ecchondrosis, and may extend horizontally for some distance. It may be met with on one or both sides; it helps to obstruct the inferior meatus, always leads to thickening of the overlying mucous membrane, and should always be removed when met with. When the septum exhibits a double curve, being warped first to one side and then to the other, it is described as representing a sigmoid flexion. This may meet and touch the inferior turbinated on one side and the middle turbinated on the other.

As might naturally be supposed, when the septum is markedly deflected we frequently find the hard palate to be very high-arched or Gothic in contour. Its transverse diameter is short, and the alveolar arch may be much more oval or relatively smaller, by which the front teeth are thrown forward and a characteristic expression given to the face. Delavan calls attention to the fact that this condition is frequently associated with the habit of mouth-breathing, and that it is often a family peculiarity.

Treatment of Deviated Septum.—For the rectification of this deformity a large variety of operative methods have been suggested, depending in their conception and for their successful performance upon the degree of deflection. It is of some interest to know that this particular branch of surgery is one of quite recent origin and development, and that almost all the operations practised for this purpose have originated within comparatively few years, although the proceeding itself, after a rude fashion, is of great antiquity. By a few surgeons, Adams for instance, it was suggested to seize the crooked septum between the two blades of strong forceps and fracture it sufficiently to allow of restoration to its normal outline. To keep it in the desired position head-bands with pads and screws, or masks with adjustable pads, or intranasal apparatus of more or less elaborate form, were called into requisition. Then it was suggested to cut out of the septum, with a punch (Fig. 237) fashioned after a conductor's punch, smaller or larger pieces of shape according to the fancy

FIG. 237.



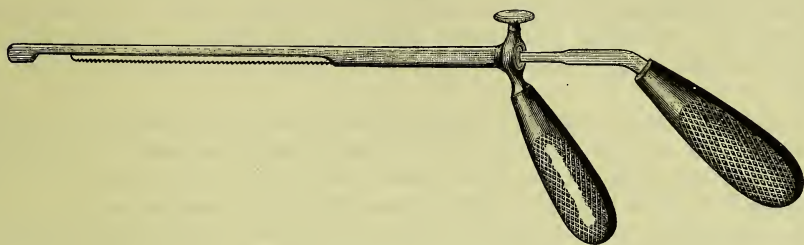
Jarvis's Punch.

of the operator, by which the septum would be so weakened as to be easy of replacement. This method is open to the objection of leaving an opening where nature did not intend one to exist, and furthermore leaves the septum so weakened as sometimes to lead

to subsequent falling in of the bridge of the nose. A much more successful

application of this form of instrument is that by which a stellate incision is made in the septum, yet without removal of any of it. This so weakens it that it can be sprung back into position, and yet leaves no perforation; but this, like all other procedures where nothing is removed, requires the subsequent use for a considerable length of time of plugs by which the partition shall be held in place until its tendency to warp is overcome. The same objection of leaving a perforation often obtains against the use of the nasal saw (Fig. 238), which

FIG. 238.

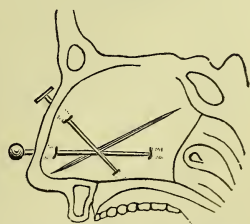


Park's Nasal Saw.

otherwise is a very useful instrument. Its especial range of usefulness is in the removal of outgrowths from the turbinated bones or of spurs or bridges from the septum. It will be spoken of again later. A very simple method for uncomplicated cases is that of incision through the protuberance along its long axis, after which the septum is forcibly replaced by means of the finger in the nostril. Its elasticity being thus temporarily overcome, it is held in place by packing the previously obstructed nostril with plugs of antiseptic gauze or of rubber or other suitable material. These are removed daily, and the parts carefully cleansed, after which the plugs are replaced. If necessary, any redundant portion can be pared with a knife or removed with a saw.

Ingals has modified this plan by incisions through the mucous membrane, its detachment from the underlying cartilage, and the removal of a triangular portion of the latter, the base of the triangle being at the floor of the nose. Of course the membrane on each side of this piece should be detached. Roberts has devised an ingenious and very effective way of overcoming septal deformity. If there is angular deflection, he makes an incision from front to back; if the deflection is a grooved one, he splits the cartilage along the most prominent portion, and cuts into the rest of the septum repeatedly until it has lost its resiliency. Any small portions that protrude at the lower margin are removed with knife or saw. If only small fragments of the entire thickness are cut away, the little perforations thus caused subsequently heal. The septum is now held in place by steel pins made for the purpose, which may be inserted through the nostril or from the outside (Fig. 239). The point is thrust through the inferior portion of the septum, which is then placed in the desired position, after which the pin is thrust still farther onward and its point buried deeply in the firm and untouched tissues at the back part of the nasal chamber. Two or more pins may be used for this purpose; they should be left a few days *in situ*. By this method the use of plugs is avoided, and antiseptic douches, powders, or sprays can be used as frequently as desired. When ridges or projections of mucous

FIG. 239.



Pins inserted for Deviation of Septum in Roberts's method of operation.

membrane are the cause of the obstruction, or even when this is composed of soft cartilage, Jarvis recommends to transfix them with a needle and then remove them with his steel wire snare.

Besides the methods thus briefly described (for more information concerning which the reader is referred to special text-books), it has been proposed to remove the offending cartilage or bone by rapidly revolving burrs or trephines operated by the dental engine, by hand power, or by small electric motors, or to attack them with fine chisels and gouges, the force being applied either with the hand or with a small mallet. When properly performed, any or all of these methods are admissible, and all are capable of affording relief. In almost every instance, however, there is necessity for long-continued care to preserve the septum in its proper place and prevent it from again warping while still weak.

Almost all these cases are complicated, however, by more or less hypertrophy of the mucous membrane of opposing surfaces, and it is relatively seldom that attention to the septum alone will suffice. This brings us to the consideration of the causes which produce this other condition.

HYPERTROPHIC AND ATROPHIC NASAL CATARRH.—The complicated structure and character of the Schneiderian membrane, as well as the fact that, especially in its lower portions, it is studded with large numbers of minute glands whose function it is to secrete the nasal mucus, must not be overlooked in accounting for this condition. These, being true glands, partake of the usual adenoid-tissue arrangement. Evidently, then, irritations which affect the membrane will also involve the glands, and the hypertrophy of one without a corresponding affection of the other is out of the question. This membrane is more exposed to external influences than any other. Thus it happens that repeated attacks of acute inflammation or the continuous action of relatively trifling irritations lead to, first, a chronic congestion, and second, tissue new-formation. This process, once begun, rapidly increases in extent and severity. The new growth is very likely to occur along that inferior turbinated bone which comes most closely in contact with a deviated and protruding septum, and, as a rule, the structures over the lower turbinated bone are much more commonly and extensively involved than those over the other bones. This diseased tissue is usually more or less spongy or erectile in character, and is composed of such a mixture of glandular and parenchymatous elements as to be commonly termed *adenoid*, the one form or the other predominating according to the type of the structure first attacked. Hypertrophy of the mucous membrane over the posterior portions of these turbinated bones is more frequent than of that over the anterior portions. The stenosis caused by these conditions may be partial or complete and temporary or permanent. Many individuals have just so much thickening as to suffer from alternate stoppage and patency of the nostrils according to the condition of the weather and their freedom from congestions due to colds. Anything which favors flow of blood to the parts will occasion stoppage. Hence some persons complain of inability to breathe in bed through that side of the nose which is lowermost. Others enjoy freedom of respiration in dry weather, while because of the hygrometric condition of the atmosphere they suffer inconvenience during damp weather, and some operators even take advantage of this latter circumstance in order to seize these growths when their increased size makes them easier to attack.

But interference with respiration is by no means the only trouble produced by this kind of hypertrophy. When the stenosis is posterior, and especially when the adenoid tissue of the naso-pharynx is involved, pressure is made upon the orifice of the Eustachian tube, with the result of more or less impairment

of hearing. It is very important to bear this in mind, since not a few cases of deafness in one ear, or in both ears, depend primarily not upon disturbance in the middle ear, but upon this condition of the naso-pharynx. Therefore in treating patients for deafness an examination of the throat and nose is as essential as an examination of the membrana tympani.

After having made a careful examination and having recognized, so far as possible, the condition above described, there is considerable range of choice as to methods for obviating the difficulty, the choice being mainly between the radical method of extirpation of the obstructing mass and that of its partial destruction by caustics or the actual cautery, trusting to the resulting cicatricial contraction to produce the desired diminution in size. The choice must be governed to a certain extent by the occupation and the personal and constitutional habits of the patient, and the means at hand. In either case local anesthesia can be usually accomplished with solutions of cocaine varying in strength from 2 to 8 per cent., using the stronger only when the weaker fail. These may be applied first by the spray, then by contact of small plugs of cotton saturated in the solution, or rarely, when necessary, by its injection into the tissues with the fine needle of the ordinary hypodermatic syringe. The operator must always expect the deeply colored and turgid appearance of these growths to be modified by the constricting effect of the cocaine. Small crushing forceps and scissors have been devised with which those parts of the nasal cavity most subject to this condition can be reached, and the hypertrophy when distinct or pedunculated can sometimes be most easily removed by their aid.

But some form of wire snare or *écraseur* is perhaps the favorite instrument for this purpose, and of the various forms of this instrument none, at least in this country, is more popular than that suggested by Jarvis (Fig. 240).

FIG. 240.



Jarvis's Snare.

Its wire loop is passed within the nose, and by the aid of artificial illumination is lodged around the base of the mass which it is proposed to remove, after which the loop is slowly tightened, and the fine wire cuts its way through the tissue so slowly that, vessels being crushed across, the operation is almost bloodless. In the attack upon posterior hypertrophies the manipulation is sometimes quite difficult and requires the skill of an expert. It is made more difficult by the sensibility of the part and by the reflex motions of the palate and pharynx, which are usually beyond the possibility of voluntary control. These are in some measure obviated by the use of palate retractors, or by the introduction of tapes through the nostrils into the pharynx and bringing them out through the mouth and tying them in front of the upper lip. By their aid not only is the palate retracted and its movements controlled, but illumination of the parts is also possible. These masses are sometimes removed with a peculiar burr attached to some revolving mechanism, by which removal is made as effective, though much more bloody.

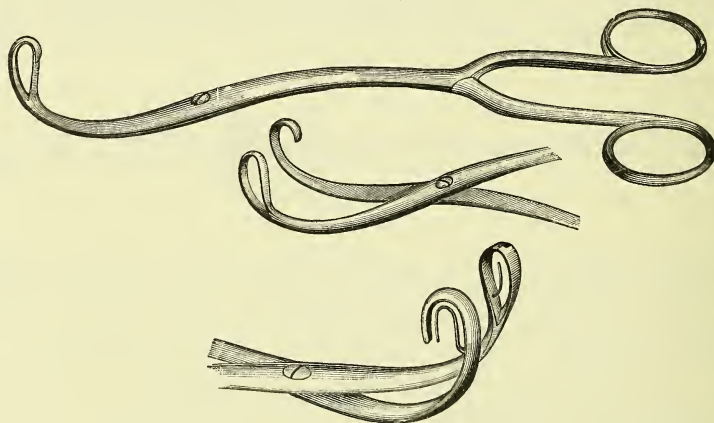
The other method of treatment, by the use of caustics, avoids some of the unpleasantness of an operation, but usually produces much more pain and discomfort, while snaring off a mass of adenoid tissue with the wire loop causes frequently very little pain.

An even more effective and commonly less painful method, certainly one which leaves fewer unpleasant immediate consequences, is the use of the galvano-cautery: the parts being prepared as above, the galvano-caustic knife or point is applied as was the caustic, and is made to burn more or less deeply and widely according to the effect desired. The resulting sloughs separate in about the same length of time, and the after-treatment in each instance consists mainly in local cleanliness and antisepsis. The final benefit may not be obtained until after the lapse of a number of weeks. This latter procedure of course implies the possession of a suitable cautery or storage battery and the necessary electrodes or cautery points, all of which are expensive. But when it is applied with skill the result is usually very satisfactory.

A collection of adenoid tissue seldom exceeding 7 or 8 mm. in diameter has been described by Luschka as the pharyngeal tonsil. This is found at the vault of the pharynx, and may become enlarged under the same conditions as those which give rise to hypertrophy or as those which produce adenoid tissue in the nose.

The *pharyngeal tonsil* is itself of interest, since along with another collection of similar tissue spread out at the base of the tongue it constitutes what has been called the ring of adenoid tissue around the pharynx, the principal portions of this ring being of course formed by the faucial tonsils. When this tissue in the pharynx is involved in hypertrophic changes, it must be removed, either with spoons fashioned for the purpose or with cutting forceps with somewhat dulled edges (Fig. 241). When diseased it may

FIG. 241.



Raynor's Naso-pharyngeal Scissors.

produce various reflex disturbances of about the same character as those mentioned under Neuroses of the Nose.

The Lingual Tonsil.—Completing the circle of glandular tissue around the oro-pharynx there is more or less of lymphoid and adenoid structure across the base of the tongue, which, described together, has been known as “the lingual tonsil.” The principal difference between it and the faucial is that the adenoid tissue here is disseminated in small groups over a considerable surface. There are here no glands, properly speaking, nor excretory ducts nor outlets, but small enclosures, three or four lines in diameter, of adenoid material covered by mucous membrane. These follicles much resemble Peyer’s patches in the intestines. They exist in the normal condition,

but they become much hypertrophied, and of about the size attained by lesions of adenoid tissue in the other parts of the pharynx. They are located between the circumvallate papillæ and the epiglottis, and are inconspicuous except when enlarged.

Normally, there is a free interval between the base of the tongue and the epiglottis, but this is more or less encroached upon when this tissue is hypertrophied, and sometimes the tip of the epiglottis may seem almost buried in a mass of tonsillar structure. This hypertrophy may even extend laterally to a considerable extent. When carefully viewed these masses will be seen to form an aggregation whose component parts may be distinctly distinguished. When these tissues are hypertrophied, there is sometimes complaint of pain shooting up toward the ears, or there may be reflex discomfort in the larynx or along the course of the pneumogastriæ; and when inflammation complicates the hypertrophy there may be actual sharp pain. The voice is more or less altered, and fatigue in speaking and singing is a common symptom. In certain cases the voice is made uncertain and unreliable. Most patients suffer from more or less reflex cough, either violent, spasmodic, or incessant, or else of a hacking character. Part of this cough is due to friction between the tongue and the glottis. It is quite likely that the so-called "globus hystericus" is in many instances a sign of value, and due to the presence of enlargements of this lymphoid tissue. Dyspnea and even asthma may occur in patients with enlarged lingual tonsils. The only radical treatment consists in the removal of the hypertrophies by caustics or mechanical measures. The latter will consist either of the wire snare or of the sharp spoon in some of its modifications. The galvano-cautery is often resorted to, and is probably the most satisfactory method of treatment. These operations can usually be made by aid of cocaine without pain.

ATROPHIC CATARRH.—This is to a large degree a result of the previous form, which when untreated has gone on to such complete formation of new connective-tissue elements that the glandular portion has disappeared. The result is now not so much the impediment to respiration as the dryness of the parts, by which the patient's comfort in breathing is very materially diminished, and he has probably by this time, if not before, become changed from a nose-breather into a mouth-breather. Still, with all this, there may be such relics of previous hypertrophic obstruction as to call for purely surgical relief by one or another of the methods above described. This form of disease is likely to be more offensive than the previous, since the dried and thickened mucous membrane is covered with crusts of desiccated secretion, which may be more or less advanced in decomposition or which may cover over actual ulceration in the tissues beneath. In this way we may have to deal with a combination of atrophic catarrh and ozena. On account of the length of time required to bring about this condition these cases pursue a very stubborn and chronic course. Their treatment is, first, local cleanliness; second, the removal of any actual obstruction; third, applications to whatever ulceration may exist; and finally, the endeavor to stimulate the long-disused remaining glands into greater activity; in other words, the restoration of the natural secretion. This is to be accomplished mainly by stimulating and antiseptic sprays or other applications, fluid or dry. It will require daily attention at least by the patient himself, and often by the surgeon, and is a process so slow as often to lead to discouragement and disappointment. Nevertheless, if carefully persisted in, it may be productive of great good, if not of complete restoration of the normal condition.

NASAL CATARRH.

Besides the acute and chronic forms of inflammation of the Schneiderian membrane already referred to under the headings of Coryza and Adenoid Thickening, there is another form of chronic inflammation which is as common perhaps as any, and which deserves consideration by itself under the term of chronic catarrhal inflammation. This may begin almost as a chronic condition, or may be secondary to acute inflammations. As a rule, the more chronic the condition the more it involves the posterior nasal surfaces along with those of the pharynx, and we have practically to deal with a retro-nasal or naso-pharyngeal catarrh. Narrowness of conformation may exert some predisposing influence. Nevertheless, the condition prevails in all countries and climates; but it appears to be most frequent where atmospheric changes are most sudden. For the treatment of this condition, which is in the main medical, the reader is referred to special text-books.

ULCERS.

Ulcers and ulcerations within the nasal cavities may be of the following types: 1. Catarrhal; 2. Tubercular (and Lupous); 3. Syphilitic; 4. Leprous; 5. Malignant. It seems hardly necessary here to go into a description of each of these forms. Their nasal characteristics in no wise differ from those which the same forms of lesion display elsewhere. Among the first must be reckoned the kind of ulceration which one may see where two surfaces which were not intended to touch each other have come into contact, or which the surface of a nasal polypus, for instance, may exhibit. Tubercular ulceration of anything like long duration will probably be accompanied by caries or necrosis of the underlying bone. The same is true of the syphilitic form. Leprous ulceration cannot be considered apart from general leprous disease, nor can it so occur. Malignant ulcers are simply expressions of degeneration of malignant neoplasms, and, while they may be regarded as among their disagreeable phases, the ulcer itself is of little consequence as compared with the primary disease, unless it produce frequent hemorrhages.

In the above statement no note is made of two or three other specific varieties of ulcerations which may occur in the nose, such as those accompanying glands, actinomycosis, etc. These are so rare in this country as to deserve only mention.

The treatment of each of these forms must be obvious. The catarrhal ulcer needs only cleanliness, freedom from irritation, and proper restoration to a condition of healthy granulation, in order rapidly to heal. The tubercular form may require removal of diseased bone, and certainly should be thoroughly cauterized or scraped, after which it can be coaxed to heal by simple measures, unless the systemic infection be too pronounced. The treatment of the syphilitic form is inseparable from that of constitutional syphilis, and calls for anti-specific medication. When one has to deal with a malignant ulcer in these parts, the question is in the main whether the primary disease can be removed by operation, no matter how severe, or not. If it appear that it can be, no time should be lost in practising it. If, on the other hand, the case appear inoperable, much may be done by repeated curetting, or destruction of neoplastic tissue with the actual cautery, or its removal, or at least the removal of so much of it as is accessible, with the scissors, knife, or snare. In this way, without thought of radical cure, life may frequently be prolonged or made less offensive both to the patient and to those around him.

EPISTAXIS.

The term epistaxis originally denoted bleeding from any point about the nose, but is now generally limited so as to mean hemorrhages from the nasal and connecting cavities. It may occur either as the result of trifling or severe injury or spontaneously, and it may be active or passive. No mucous membrane in the body is so naturally disposed to bleed both by liability to insult and by character of construction as that which lines the nose. Hyperemia is very easily produced, and the blood-vessels of the part have little or no natural support outside of their own walls. The traumatic form follows various injuries, not necessarily applied directly to the nose. Falls of all kinds will frequently produce it, and especially falls or blows upon the head. It is known to occur frequently in connection with fractures of the skull, especially of the base. It may occur from picking the nose or from rude introduction of something into the nostrils, and occasionally follows explosions of some violence; thus men handling heavy pieces of artillery, especially within small compartments, are frequently annoyed with it. When slight causes give rise to it, there is nearly always some local or constitutional predisposition, usually in the so-called full habit of body, or, in the aged, extreme fragility of vessels, or a more or less varicose condition of the parts, in those who have this condition elsewhere. The so-called spontaneous form may arise from inhalation of irritating vapors; from over-filling of the capillaries, due to violent over-action of the heart or to too severe exercise; from some act like coughing or sneezing; from previous ulceration; from the presence of foreign bodies or parasites; or from the presence of tumors; in fact, from anything which tends to produce a filling of arteries and obstruction to venous return. It is common in plethoric children and adults. It is frequently the precursor of apoplectic lesions in the brain and eye. It occurs often in passage from dense to rarefied air or the reverse, as in balloonists or those working in caissons. In such cases, in fact, it is to be regarded as an apoplexy of the Schneiderian membrane. It is a symptom of several acute diseases, for instance of typhoid, and accompanies scurvy, purpura, chlorosis, etc.

It may be of a vicarious character, and may then occur from suppression of menses, urine, or perspiration, or even of hemorrhages from varicose veins or malignant tumors. Children approaching the age of puberty seem to be liable to it, and some pregnant women frequently suffer from it. Extremes of heat and cold upon the surface seem often to favor it, and psychical impressions are occasionally sufficient to excite it. In degree and extent it may vary from the escape of a few drops of blood to a hemorrhage so violent as to endanger life or even terminate it. It usually comes from one nostril, sometimes from both, and may escape through the naso-pharynx into the mouth, whence it may be expectorated or swallowed. The presence of blood which has thus entered the stomach may excite the act of vomiting, by which still further hemorrhage may be favored. As a rule, it escapes from some point in the anterior nares, perhaps more often upon the septum than elsewhere.

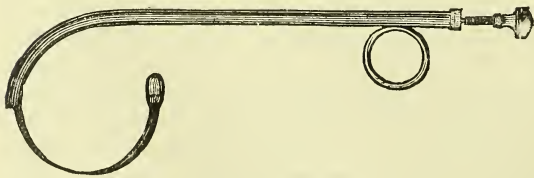
The **diagnosis** seldom offers the slightest difficulty; only in some cases of grave constitutional disease where blood runs down the trachea or œsophagus without the knowledge of the patient can uncertainty arise. While in general epistaxis is to be checked at once, there are circumstances which may make this inadvisable. If, for instance, it appear to be a relief of supercharged intracranial vessels, it should be regarded rather as an advantage than otherwise, and checked only in case it become excessive. Many congestions of the brain and important parts within the skull have been relieved by this spontaneous

venesection. But, as a rule, it is something which should be checked as soon as practicable, especially if collapse threaten.

Treatment.—To begin with, if possible, the cause should be ascertained and removed. Removal, however, is seldom practicable, and treatment must depend upon the exigencies of the case. First of all, position and rest should be attended to. Naturally the higher the head the better, and patients should not be allowed to lie down unless they be very weak. All pressure of clothing about the neck and thorax should be removed, and patients should be cautioned against coughing and sneezing, as also particularly against constant efforts to blow the nose and thus expel the blood, since by this act the formation of a clot is prevented. It has been found that extension and elevation of the arms above the head produce, by reflex vaso-motor mechanism, contraction of the nasal vessels, as does also sometimes pressure at the root of the nose or about the nasal region of the face, and these measures are to be recommended as worthy of trial. Pressure against the bone upon either side of the ala nasi will often check epistaxis occurring from the anterior portion of the nose, as the lateral nasal vessels supply the mucous membrane of this portion of the nasal cavities. Pressure upon the carotid would also be indicated were it not that the jugular vein is obstructed at the same time. The application of cold to the back of the neck, ice-water enemata, and similar measures may also produce reflex vascular spasm within the nose. If these measures be found inefficient, astringents may be employed by the nasal douche, such as ice-water or water as hot as can be borne, or solutions of alum, tannin, etc. The stronger the astringent, however, the more disagreeable the general effect, and if the bleeding point can be localized it will be much better to apply some dry astringent directly to the part. It has been a common practice to employ tents within the nostrils or to pack the anterior naris with some material like cobweb, which not only acts as a styptic, but also serves to entangle the blood and favor coagulation. For cases of moderate severity or for hemorrhage following ordinary intranasal operations the writer has found a solution of antipyrine, of 5 to 10 per cent. strength, the most serviceable and the least disagreeable. Its effect upon the blood-vessels is like that of cocaine, only more lasting, and it makes a very serviceable styptic for general surgical purposes, since to its astringent properties is added that of being antiseptic.

When hemorrhage is alarming, however, it is better not to waste time with measures of the above character, but to proceed at once to plugging the nasal passages. If the hemorrhage be anterior, the introduction of tampons through the nostril may be quite sufficient. A series of these should be tied to a single piece of stout silk, by means of which all are under control. If, however, this be not enough, the posterior naris may be occluded by a very simple procedure which gives rise to no particular pain. The most serviceable instrument for this purpose is the little canula devised by Bellocq (Fig. 242); but in the

FIG. 242.



Bellocq's Canula.

absence of this an ordinary silk catheter may be armed with a piece of stout silk or twine by threading one end of a piece, 15 inches long, through its eye. This catheter is now passed in along the floor of the nose until it is deflected downward by the posterior wall of the pharynx.

So soon as its point is seen behind the uvula the silk thread may be caught with

a tenaculum or forceps and drawn out through the mouth, while the catheter is withdrawn from the nose. One end of the thread is now hanging from the nostril, the other from the mouth. The middle of the latter is firmly tied around a pledget of cotton or of sponge, which is then drawn backward and upward by pulling on that portion which hangs from the nose, guiding the tampon with the index finger of the other hand over the tongue into the pharynx and then up and behind the soft palate. It is an advantage if the portion which still hangs out from the mouth have been left so long that, a day or two later, when it is desired to remove the tampon, this may be done by pulling downward again by means of this portion rather than having to dislodge the plug with curved forceps in the pharynx or to push it backward by something introduced again within the nose. If this end be left long enough for this purpose, it may be brought out of the mouth and knotted to the other end, so that by means of this continuous loop perfect control of the tampon is afforded. After plugging the nostril posteriorly, anterior plugs may be inserted in case the other be found insufficient. This method is usually very effective, and if the plugs be not left so long in place that decomposition takes place, it is quite safe. Posterior plugging without means of control by attached threads is by no means free from danger, since death by suffocation during sleep has been known to occur from its spontaneous dislodgment. Such a plug should never be left in place for more than two days. If there be necessity for longer protection it should be renewed. Plugs inserted through the nostril should be tied successively to a single piece of stout silk, so that later they may be easily dislodged and withdrawn by pulling gently upon its anterior end.

FOREIGN BODIES.

The ears and nose alike are exposed to the introduction of foreign bodies either by accident or by design. This occurs naturally most frequently in children who have not yet reached the age of reason. A list of possible foreign substances would include almost everything of size not too large to enter the nostril, and no attempt need be made to catalogue them. Introduced nearly always from without, it may be possible for them to enter from the naso-pharynx, as when a substance is taken into the mouth and almost swallowed, being finally expelled, not into the mouth again, but upward into the posterior nares. These substances are by no means necessarily always inert, since insects not infrequently effect an entrance into the nostrils. A small particle is usually expelled by a reflex act as soon as introduced, but if it remain long it may gather about it sufficient tenacious mucus to retain it in place or even enable it to resist expulsion. On the other hand, a mass which is large enough to be introduced with some difficulty or one which by imbibition of moisture may expand may give rise to a great deal of trouble in its removal.

The signs and symptoms of foreign bodies in the nose are usually unmistakable. Little children will sometimes not give evidence of their presence until decomposition or bleeding or profuse discharge attracts attention.

Treatment.—When the foreign mass is visible with ordinary artificial illumination, it can usually be grasped with forceps and removed or be dragged out after the insertion of a small hook or tenaculum point, and ordinarily there is nothing difficult about this manœuvre; but young children are frequently so uncontrollable that the assistance of an anesthetic is necessary, and the surgeon can accomplish in a few seconds by the aid of chloroform that which would require a long struggle without it. At times when the mass is

located too far back within the inferior meatus for easy withdrawal it will be found much easier to pass in some simple instrument and push it backward so that it shall drop into the naso-pharynx, whence it should be removed by the surgeon himself in order to avoid further complications. Sometimes sudden forcible blowing into the other nostril by means of a tube over the end of which the nostril is closed will expel the foreign body. Only when some simple procedure of this kind fails—and this will be very rarely—will anything in the nature of an operation be required. If it be a piece of metal or something rigid which has been already lodged in a position not permitting withdrawal, then it may be necessary to cut away some portion of the turbinated bone or make some atypical operation according to the exigencies of the case.

RHINOLITHS.

These are calculi or calculous concretions varying in size from 1 mm. to 2 or 3 cm., which are formed, much as are those in the bladder, by the deposition of alkaline salts, mainly phosphates, around a foreign particle within the nasal passages. This foreign particle may be a small mass of desiccated mucus. They are usually unilateral, and commonly lie against the septum or within the inferior or the middle meatus. The general congestion or inflammatory changes around them may give rise to symptoms already described.

When the rhinolith, as such, produces **symptoms**, they are much like those produced by any other foreign body. Nasal discharge and obstruction to respiration, with accompanying alteration in tone and voice, and perhaps anosmia (loss of smell), will be the most common results. If any portion of such a concretion presents to the view, it will probably be discolored and perhaps almost black, appearing much as necrosed bone in the same location often does, and may be mistaken for it. Furthermore, its gritty surface may increase the liability to error; but it is very seldom that diseased bone alone will give rise to so much fetor as accompanies an aggravated form of rhinolith. Careful examination of the nasal cavities after approved methods will enable a diagnosis to be made, after which it will probably be an easy task with suitable dressing forceps or a small spoon to dislodge and remove the concretion. If necessary, and if no tissue around it calls for removal, the rhinolith may be broken into pieces, being usually very friable, and removed piecemeal.

PARASITES.

The parasites which infect the nasal passages are mainly insects and worms. In this country they are very rare. In the tropics such cases are frequent, and sometimes of serious character. Danger comes not so much from the adult insect as from the larvæ which it may deposit, and which may be aspirated into the deeper cavities with inspiratory movements. Almost the only parasite found in this country in the nose is the maggot. In certain catarrhal and ozenous affections there is sometimes such fetor of discharge as to attract flies, which penetrate the nasal cavity during sleep, deposit eggs there, and leave them to be hatched as maggots, their incubation being favored by surrounding warmth and moisture. By any of these larvæ the mucous membrane may be destroyed, and the cartilage and the bones become necrosed.

The principal symptom is an itching in the nose which sometimes becomes intense, with various ill-defined but well-located disagreeable sensations, which in nervous and susceptible children may precipitate convulsive attacks. Almost always there will be reflex headache, especially in the frontal region. Hemor-

rhages may occur there purely as the result of ulceration or of violent expulsive efforts. Sometimes a cellulitis of the nasal region of the face may be set up, and swelling may be so severe as nearly to close the eyelids. In the tropics the condition may be fatal within a few hours, from local and general disturbance. Antiseptic douches and inhalations of chloroform vapor or of a solution of iodine in chloroform will be effective in destroying the parasites.

POLYPI AND TUMORS.

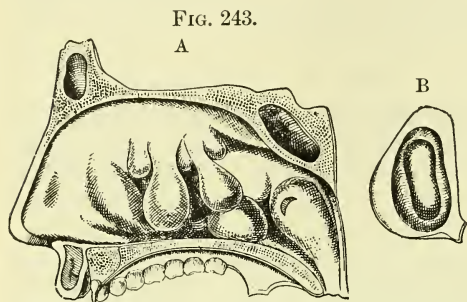
The principal neoplasms of the nasal cavities are myxomata and myxofibromata, which usually occur in polypoid form, vascular tumors, adenomata, exostoses and osteomata, enchondromata, and the malignant tumors, including various forms of sarcomata and carcinomata. Of these the **polypi**, which are usually nearly pure forms of myxomata, are the most frequent. They are composed of very soft tissue of gelatinoid consistence, varying a little in firmness according to the amount of fibrous tissue which they contain. They are usually pyriform in shape and pedunculated, of a pale flesh tint, almost translucent, varying in size from that of a pea to that of an almond, and annoy mainly from the discomfort which they cause and their obstruction to respiration. The causes of nasal polypi are very obscure. Certainly it cannot be chronic inflammation alone, otherwise they would be met with in a large majority of individuals. Men are more liable to them than women, and children usually escape. They are met with sometimes singly; at other times they occur by dozens and form a cluster, several of which may perhaps be removed at one time. Some of these are throughout of the same consistence, others have a cystic interior; they are covered with epithelium, and have very few vessels, if any, and no nerves at all. The ordinary mucous polypi do not adhere to the bone. Those which spring from parts beneath the mucosa must be largely fibrous in their structure. If they grow rapidly they cause more disturbance than when of slow growth.

So far as their location is concerned, they grow most frequently from the middle turbinated body, next from the superior turbinated bone and meatus. They rarely spring from the lower turbinated bone and meatus; in other words, they will usually be found in the upper and more anterior portions of the nose. They almost never spring from the septum. While they may extend backward into the naso-pharynx or occasionally into the sphenoidal sinus, they never fully escape spontaneously from the nostrils. When of considerable size they may adhere at different points, so that the determination of their pedicle is difficult. It is stated that the pear-shape forms arise from sharp prominences, while those with broad bases arise from flat surfaces.

Symptoms.—These are at first insignificant and vague. The patient usually complains of copious secretion from the nostrils and of difficulty in breathing through one or both of the nares. Later comes complaint of some discomfort, and the patient will frequently snuff in the endeavor to free the nostrils from some obstruction. After a while the secretion becomes mucopurulent, with perhaps unpleasant odor, and the voice acquires a peculiar twang which is always indicative of nasal obstruction. Perhaps the occurrence of epistaxis may be the means of directing especial attention toward the nose. The symptoms are augmented by humidity of atmosphere, since mucous polypi are very hygrometric. Respiration may become audible, accompanied by a whistling sound. These signs and symptoms will vary, of course, with the extent of the disease. Aside from these purely local features, there occur more or less frequent reflex disturbances, among which should be mentioned asthma, cough—often distressing—hemicrania, facial and cranial neuralgia,

vertigo, and even epilepsy. When the nasal cavity is filled with polypi, the nose often becomes more prominent and distended (Fig. 243).

It is of course taken for granted that any complaint of nasal obstruction will lead to a careful examination of the nose. Nasal polypi can scarcely be taken for anything else save possibly adenoid and catarrhal hypertrophy of the mucous membrane. When cocaine solutions are applied to the former, they are not at all affected, while the latter at once shrink and retract under their influence. It will be found also that a probe carefully manipulated may be passed under or around the ordinary polypus, so that it can perhaps be moved, or as it were swung, from its stem, while it may often be seen to sway or move



A, Mucous Polypi in the Nose; B, anterior view of same, normal size (Sajous).

in a current of expired air. Aside from the local reflex annoyance which it causes, the condition can scarcely be considered dangerous. There is a great liability to recurrence after removal, which is due undoubtedly to failure to make extirpation complete and to cauterize and destroy the surface or base from which each polyp has sprung. Moreover, when the condition is multiple, minute or incipient polypi may elude observation, develop later, and take the place of those which were removed. Furthermore, the very causes which operate in the first place to produce them may continue so to act.

While polypi may be spontaneously expelled, their proper treatment is always surgical. Formerly the endeavor was made to inject into them some escharotic, such as acetic, chromic, or carbolic acid, or some powerful astringent; but safer and more dexterous manipulations have taken the place of these rude attempts, and measures for their removal now include avulsion, excision, and the galvano-cautery. By avulsion is meant the use of forceps of suitable device by which the polypus is seized as firmly as may be, and with as little force as is necessary twisted off from its base. If the operator know thoroughly his anatomy and can make out the exact location of the growth, he will work much less in the dark than according to the old-fashioned way of practically tearing away with the forceps whatever they may seize. This latter method is painful and bungling, and likely to produce copious bleeding, whereas the former is satisfactory so far as it goes. The naris should be illuminated, and when the polyp can be neatly grasped it is better to twist it off by revolving the instrument until it is dislodged than rudely to tear it away. In this as in the other operations cocaine solutions give the greatest aid, not only by obtunding sensibility, but also by causing retraction of surrounding tissue and better exposure of the growths.

For excision or abscission a most serviceable instrument is that form of écraseur devised by Jarvis, by which pedunculated growths can be bloodlessly and almost painlessly removed (Fig. 240). Some dexterity and practice are necessary for its skilful manipulation, yet these may be easily acquired. The base of the growth is caught by the wire loop, and its size rapidly or slowly diminished according to the amount of discomfort caused. After removal of the polyp its base should be cauterized with some chemical caustic or the galvano-cautery. Of course both indications are carried out when the galvano-caustic loop is employed. The principal objection to this

method is the number of repetitions usually necessary to secure entire removal of myxomatous tissue. Almost always after thus operating some local treatment will be found necessary in order to overcome the condition of chronic hyperemia or inflammation consequent upon it.

Naso-pharyngeal Polyp.—A denser and more fibrous form of polypoid growth, composed of mixed mucous and fibroid tissue, occurs farther back in the nose, and occasionally polypoid tumors of nearly pure fibromatous character springing from the periosteum or the bone at the base of the skull or the adjoining facial bones will be found projecting into the pharynx. These become of more serious nature in proportion to the amount of fibrous tissue they contain, since the latter will prove a pretty accurate index of their vascularity.

When these spring from the septum or turbinated bones, they can usually be removed by the expert with the snare or the galvano-caustic loop, but a genuine fibroid growing from the base of the skull and projecting downward into the naso-pharyngeal cavity is an affair of a most serious nature. For the removal of such growths operations of the greatest magnitude have been undertaken, with varying success. The upper jaw of one side has been resected, or the roof of the mouth cut away, or both upper jaws so far loosened from their connections as to be temporarily depressed, an incision being made clear across the face, by means of which extensive operative procedure access has been gained to the naso-pharynx. Even after this has been done the removal of the growth is by no means an easy matter, and the writer has seen in one case a patient perish on the table from hemorrhage from one of these growths during such an operation, which even the skill of a celebrated surgeon could not check. Langenbeck's osteo-plastic resection of the upper jaw consists in an incision from the inner angle of the orbit to the malar bone, and a second from the nostril to the malar bone, joining the first. The soft parts are left adherent to the bone. The bone is then sawn through both incisions to the retro-maxillary fossa, which is exposed, when the bony flap thus made hinging on the central line of the nose is thrown over on the opposite cheek. This lays open the whole naso-pharyngeal cavity and retro-maxillary space. The parts are then returned to their normal position after removal of the tumor.

VASCULAR AND OTHER TUMORS.

Angeiomata in the nose are rare. They are to be sharply distinguished from a simple varicose condition of a limited area of mucous membrane, which is quite common. They occur mostly in males during adolescence. Of the symptoms, epistaxis is the most frequent and most prominent, the bleeding being most profuse and persistent.

Adenomata.—Enough has already been said to show that a multiple adenomatous affection of the mucous glands is very common, and such enlargements constitute the principal type of adenomata occurring in the nose. As a rule, they are inseparable from hyperplasia of the surrounding tissue. Transformation from adenoma into carcinoma, though infrequent, is well known to occur. When met with, the tumor must be removed after the approved fashion with the cold or hot wire loop.

Exostoses and Osteomata.—Outgrowths of bone which after a fashion simulate physiological or normal protrusions are to be considered as exostoses, while those which bear no such resemblance are termed osteomata. These are sometimes of cancellous bone, but more often of compact bony tissue. They are not common, are most often met with in the young, and at times may attain large size. The symptoms which usually attract attention are increased dis-

charge of mucus, hemorrhage, a feeling of obstruction and of discomfort or itching, sometimes severe neuralgic pain, and perhaps loss of smell. Proper examination will reveal the obstruction, and the probe or other instrument must be used in order to determine by its hardness and rigidity whether it be composed of soft tissue, cartilage, or bone. If of long duration there may be ulceration and even necrosis. If the latter have taken place there will be a fetid discharge which will certainly attract attention. In size and shape they vary very much. Fortunately, it is usually easy to separate them from the bone from which they spring. This removal may be effected with the wire loop, with stout scissors adapted to the purpose, or with one of the forms of intranasal saw. In a few instances when the growth was large and firm it has been found necessary to lay open the nose so as to expose well the nasal cavity of one side; but such operations are done much more often in Europe, since American ingenuity has devised the dental engine or its substitutes, by means of which a rapidly-revolving trephine or burr may be made to cut away even firm osseous tissue with little shock and with no necessity for external incisions.

Enchondromata.—These are much more rare than bony tumors, although an enchondrosis corresponding exactly to the idea conveyed by the term exostosis is a very frequent occurrence in the nose, forming a cartilaginous spur or projection often seen on the septum. Their detection and removal in no wise differ from those of bony growths, and need no further description here.

Malignant Tumors.—Although the nose is frequently involved in cancerous growths, they are rarely of primary origin in this locality. Even with all the irritations to which the Schneiderian membrane is exposed, primary epithelioma is very uncommon. Sarcomata arise more frequently from the septum, while epitheliomata are perhaps equally common upon the septum and upon the turbinated bones. While thorough extirpation here as elsewhere is the only serviceable method of treatment, this may be done perhaps better by the actual cautery operated through the natural passages than with more formidable cutting operations. If complete destruction can be accomplished safely by some chemical means, such as lactic acid, there is no reason why it should not be as effective as removal by operation. In proportion as these growths affect the parts nearer the pharynx they become less accessible, more likely to infiltrate and affect the surrounding lymphatics, and both more difficult and more dangerous to attack by operation. Still, whatever good is to be accomplished in such cases must be achieved either by use of instruments or by the galvano-cautery.

AFFECTIONS OF THE SINUSES.

FRONTAL SINUSES.—**Injuries.**—These occur, as a rule, from direct violence upon the forehead, which may cause either simple, compound, or comminuted fracture of its walls. Simple fracture, with absence of cerebral symptoms, is common. It may be complicated by emphysema of the surrounding soft parts, which may occur through the escape of air from the nose. If there be depression of the outer table, it should be elevated to prevent deformity. Compound and comminuted fractures may be complicated by the lodgment of a foreign body. They are made more serious when the posterior wall is also broken and the dura exposed. Operative interference is always indicated in such a case. They are known to have been followed sometimes by fistulous openings through which air may pass, and plastic operations have been made for their closure.

Foreign Bodies are either introduced from above or make their way upward from the nose. The latter are usually insects which creep up and may either die there or deposit larvæ which hatch and live. It is said that centipedes have been found within the frontal sinus. These parasites, if they cause any trouble at all, will usually set up an acute inflammation which will terminate by abscess.

Inflammation.—This may be acute or chronic. When the latter, it is usually due to tuberculosis or syphilis. Inflammation may be the result of extension from the mucosa of the nose or from the surrounding bone. According to its intensity will be the severity of its symptoms, which consist in the main of pain and headache and a sense of weight and fulness in the forehead, with usually the symptoms of acute coryza. The local signs are swelling and tenderness, more or less fever, rigors, and even delirium in the most acute cases. When pus has formed and has escaped from the sinus proper into the cranial cavity, it may produce various pressure-signs. An erysipelatous blush of the overlying skin sometimes occurs. When the disease is of syphilitic origin there will be other signs of the constitutional condition. When of tubercular origin it will probably be accompanied by caries or necrosis of the enclosing bone, with other local manifestations.

A collection of pus in the frontal sinus is often spoken of as **empyema** of the same, which, if old, will have produced marked change in the external contour of this part of the face. The roof of the orbit is sometimes depressed, and even the globe of the eye altered in position. When long existent the bony wall may have so far disappeared by absorption as to yield a kind of parchment crepitation upon pressure, with fluctuation underneath. This purulent collection tends to evacuate itself spontaneously in the direction of least resistance, which may be either externally into the nose or orbit or internally into the ethmoid cells or the cranial cavity.

When signs of inflammation first present themselves here, leeching will often afford relief. This may be combined with whatever other treatment is suggested by the condition within the nose; but just so soon as signs of pus are present or of cerebral disturbance or any other serious condition, no time should be lost in perforating the external surface with a small trephine or other instrument and cleansing and draining the cavity. In spite of the resulting scar, it is wiser to do this by external incision rather than by operating through the nose, as many have done in time past.

Cystic Dilatation or Dropsy of the Frontal Sinus has been described by various writers, as well as **hematomata** and **hydatid cysts**. It is enough here to mention the possibility of their occurrence, referring the student to the larger treatises for their further description.

Tumors also occur within this sinus, both benign, like **myxoma** and **fibroma**, and malignant, such as **sarcoma** and **scirrhus**. If considered suitable to attack, they must be removed by external incision. The entire thickness of the frontal bone has been more than once removed in order to extirpate growths of this kind, and, providing the condition of the patient be at all favorable, no operation can expose to so much damage and danger as does such a tumor.

ETHMOIDAL CELLS.—The ethmoidal cells are liable to affection by direct extension from the Schneiderian membrane, by which they are occasionally involved in catarrhal thickening, polypoid growths, and even caries with perforation of the bones of the skull, according to Virchow. Diphtheritic disease has also extended as far as these cells, and it is stated that a frequent cause of **ozena** is to be found here.

SPHENOIDAL SINUS.—What has just been stated with reference to the

ethmoidal cells holds good also with reference to this sinus, but with this difference, that disease here is more favorably located for surgical relief. Escape of cerebro-spinal fluid has been observed after injuries of this sinus. Furthermore, by virtue of its intimate relation with the internal carotid and the cavernous sinus, injuries to these vessels have followed wounds to this bony cavity, and pulsating exophthalmos has been known thus to result. Caries and necrosis of the body of the sphenoid may produce lesions of the nerves above mentioned, separation of fragments of bone, hemorrhage which may be fatal, retro-pharyngeal abscess, thrombosis of the cavernous sinus, and perforation of the base of the skull. We may also have an empyema of this cavity from causes similar to those mentioned before, the signs and symptoms of which would include headache and spasmodic and sympathetic affections of the nerves in intimate relation with it; for example, photophobia and blepharospasm. The sinus has been operated upon in recent years by three different paths: through the naso-pharynx; through the orbit after enucleation of the eye; and by the nose, which seems to be the preferable route.

Tumors of the same character as those which involve the frontal sinus may also be met with here, although much less amenable to operative relief.

THE ANTRUM OF HIGHMORE, OR THE MAXILLARY SINUS.—The outer wall of this cavity is quite exposed, and is liable to simple fracture by a blow, or to compound injury with perforation by a weapon or other foreign substance. The entire cavity is sometimes perforated by a foreign body, such as a bullet. When the outer wall is depressed by injury or comminuted, it may perhaps be elevated by instruments introduced directly or from within the mouth or nose. Swelling of the overlying soft parts, which may occur very frequently and very quickly, will sometimes mask a depression of the bone. Mistake can be best avoided by exploration with the finger in the mouth.

The antrum is sometimes filled with blood, either as the result of injury from without or as the result of epistaxis. Almost always after plugging the nose blood will force its way into the cavity. Ordinarily it will be easily and quickly resorbed, but decomposition may result and abscess ensue. Insects and foreign bodies may also exceptionally be found in it.

The most common affection of the antrum is **inflammation** with subsequent **abscess**. This may be the result of a propagation of the inflammatory lesion from the nose, or not infrequently of disease following up the roots of the teeth, which sometimes project a little distance into this cavity. As to the former, it may be said that the average size of the opening of the antrum into the middle meatus of the nose is 4 by 8 mm. A second opening rarely exists, and has been ascribed by Giraldès to a rarefying atrophy. When we remember the ease of communication from one cavity to the other, the wonder is that abscess does not occur much more frequently than is the case. Not a few cases have followed attacks of the grippe in which the nasal symptoms were especially severe. The presence of polypi appears to be sometimes the exciting cause. The second form appears to be an extension by an alveolar periostitis which is the result of dental caries; and a third form may arise from purely traumatic causes.

Whatever the cause, the symptoms are about the same, consisting of local pain radiating in various directions, especially toward the nose, swelling of the overlying soft parts, and thinning of the bone so that sometimes it gives rise to a parchment-like crepitation. If the nasal outlet be still patulous and pus be present in the antrum, it will be found that in certain positions of the head it will flow into the nose, passing either anteriorly or posteriorly. When this pathognomonic symptom is present the pus is very frequently offensive.

With the nasal speculum it may perhaps be seen trickling into the nose. When the symptoms are very severe there may occur an expansion of the whole jaw with elevation of the malar bone, displacement of the eyeball, extreme alveolar tenderness, and extension of trouble along various nerve-sheaths, with spontaneous perforation in some direction if timely relief be not afforded. Percussion over the two antra will reveal a dull sound on the side of the abscess. Attention has been called to the possibility of deriving information from the use of an electric light in the mouth, but Zeim does not think the diagnosis of suppuration in the antrum can be made with any certainty by this means. Between long-existing abscess, cystic degeneration, and tumor within the antrum there may be some difficulty of diagnosis, but the presence or absence of early signs of inflammation will aid as between the first two, while as between cystic degeneration and tumor the existence of cachexia or of local signs of inflammation will be most significant.

The **treatment** of inflammation previous to the formation of an abscess may consist in leeching and hot applications, with appropriate general measures. When pus has already accumulated, a free opening for its evacuation is essential. If the disease has extended upward from a tooth, the old method of removal of the tooth and the perforation of the antrum at its base will be proper. But when the teeth are sound, it is a pity to sacrifice one of them for this purpose, and it is preferable to perforate the antrum at the point of election, which is above the point of the root of the second bicuspid, about an inch above the border of the gum. The mucous membrane of the buccal fold may be incised at this point and the thin wall of bone perforated with a trocar or a delicate gouge with the exertion of very little force. By this means a free opening can be made with drainage into the mouth. More perfect drainage, however, may be obtained by making a counter-opening into the inferior meatus of the nose, *i. e.* on a level with the floor of the antrum; and if this be done a drainage-tube may be drawn through from the mouth into the nose and left protruding at the nostril for a few days. This permits such thorough irrigation as to ensure reasonably rapid recovery from the empyemic condition without making the operation in any sense more severe or more serious. Daily irrigation should be practised, and one or both openings should be kept patulous with a proper packing or suitable device so long as any pus is discharged.

Tumors.—Morbid growths within the antrum are by no means uncommon, originating less frequently from the alveolar border than from the muco-periosteum. Of 307 cases tabulated by Weber, 133 were carcinomata, 84 sarcomata, 32 osteomata, 20 cysts, 17 fibromata, and the remainder miscellaneous; in other words, on the average two-thirds of the tumors of the antrum are malignant. Their general character as to benignity or malignity must be judged by their rapidity of growth and by the general condition of the patient. Their earlier stages are marked by few if any symptoms, while their later symptoms are almost identical. If affection of the neighboring lymphatic glands can be detected, the probability is that they are malignant, although it must be said of cancer of the antrum that, as a rule, the external lymphatics are slow to become involved. If a tumor be recognized in this location, a decision as to whether to operate must be formed partly upon the age and general state of the patient, and partly upon the absence or presence of signs of involvement of the adjoining and especially the surgically inaccessible parts. To this end careful examination of the nose and naso-pharynx should be made, vision should be tested, and all the nerves of special sense, as well as the motor and sensory nerves of this region, should be studied in order to recognize signs of involvement of any of them. It having been decided to operate, the operation is

practically that of removal of the upper jaw, which is described in another place. If the trouble be malignant, the surgeon cannot be too thorough in removing tissues which are even suspicious. If the neoplasm be benign, it may be enough to lay open the cheek by the usual incision for the more formidable procedure, and then to expose the interior of the antrum by cutting away its anterior wall. This will permit the easy extirpation of polypi, fibromata, cysts, etc.

INJURIES OF THE NOSE.

FRACTURES and DISLOCATIONS of the nasal bones are considered elsewhere.

WOUNDS of the nose may be contused, incised, or lacerated. They demand care in treatment mainly for the prevention of deformity. Accurate coaptation of edges, readjustment of parts in proper position, and reduction by suitable means call for a high degree of surgical skill. Some internal support, as from a rubber or glass tube or an antiseptic plug, may be advisable, and externally the collodion dressing reinforced by a few cotton fibers will be found admirable. When a portion of the nose has been actually carried away, some plastic operation for its repair becomes necessary. Experience has also shown that when the nose has been partially or even completely detached it is possible for complete union to occur if it be immediately restored to its proper position and suitably held in place. Foreign bodies, of course, should be immediately removed. Burns and scalds of the nose are of particular importance, because of possible cicatricial contraction and consequent deformity. This is bad enough at any part of its surface, but is worst of all when occurring around the nostrils. It is to be guarded against by the utmost care during the healing process, and perhaps by some artificial intranasal support, which must be worn steadily for some time and after a while may be worn only during the night.

SURGICAL EMPHYSEMA OF THE NOSE.—This occurs quite commonly after any injury by which a lesion of the mucous membrane is produced, especially after fracture and dislocation. The term implies a distention or blowing up of the cellular tissue by air, especially during the expiratory act, and is particularly likely to take place when clots of blood fill up the nasal cavity and by their presence excite the patient to frequent involuntary efforts to expel them. The condition varies from the slightest recognizable puffiness of the skin about the bridge of the nose to a most marked swelling of the soft parts about the face, eyes, and forehead, by which the patient's features may be made almost unrecognizable. When the palpating fingers are placed upon the distended tissues a very fine bubbling crepitation is at once detected. This condition, though terrifying to the laity, is one by itself of no serious importance. Only in case germs of decomposition enter and set up a septic cellulitis will any trouble follow. Should this result, the phlegmonous cellulitis might be serious or even fatal. It would call for constitutional treatment and free incisions.

RHINOPLASTY.

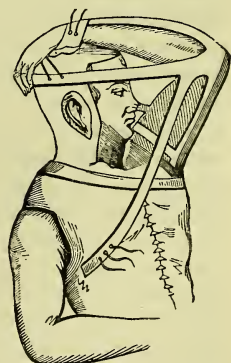
The term rhinoplasty includes all operations having for their object the restoration or repair of the nose. They are called for: 1st, for correction of congenital deformity; 2d, to repair effects of injury; and 3d, for restoration from the ravages of disease, the latter being malignant or ulcerative, with or without caries or necrosis of the bone. No operation of the kind should be performed until the destructive process has been positively checked or all actually diseased tissue removed by excision or ablation. These ope-

rations date back to the earliest days of surgery, and seem to have been successfully practised at a time when operative surgery in general was very crude. Rhinoplasty is divided into total and partial. For the relief of partial deficiencies, such as defect of one of the alæ, a flap may be taken from the upper side of the nose or from the tissues of the cheek; usually only when it requires to be very large will it be necessary to take it from the forehead. These flaps are almost invariably made by the process of transplantation, leaving a pedicle for vascular supply, which should not be twisted too tightly, lest this supply be cut off. After the flap is firmly implanted in its new position, say in from ten to fourteen days, the pedicle may be divided, or, if necessary, a redundant portion excised. An extreme condition of pug-nose has been remedied by cutting transversely across the nose, drawing the tip down to the desired position, and then transplanting flaps from the cheeks to fill the wedge-shaped defect. A new *columna nasi* is sometimes formed from the upper lip by excising a small part at the middle line and then turning the strip upward, the inside of the tip of the nose being freshened for its reception. The wound in the lip is then closed, as in the case of hare-lip, with pins or sutures. For the relief of fistulous openings on one or both sides it is necessary cleanly to excise the ulcerated or cicatrized margin, and then to slide or transplant a flap from the adjoining cheek.

For restoration of the entire nose two quite different methods have been suggested, both of which are old. The procedure is as follows: First of all, it is necessary to have an idea of the amount of skin to be transplanted. In order to do this, a pattern is made with a piece of oiled silk by fashioning it over the normal nose of some other individual, or by building up on the face of the patient with wax, clay, or dough a model of a nose which shall suit the other features. The pattern thus made will be rudely pyriform, and it will be seen that a peculiar projection is to be arranged for at the distal border, from which the *columna* or septum is to be formed. This pattern is to be used on either the forehead or the arm of the patient, according to the selection of the operator.

The Tagliacotian method (Fig. 244), named from Tagliacozzi, a famous Italian surgeon of the sixteenth century, comprehends the use of a flap of skin raised usually from the left arm of the patient. This flap is marked out upon the arm by means of the pattern already referred to, allowing one-third on every side for shrinkage, since the human skin may be always expected to shrink to about this extent after the division or raising of a flap. The original procedure includes the detaching of this flap except its pedicle, and leaving it for about two weeks in order that it may become more vascular and thickened and its lower surface covered with granulation. After two weeks the stump or remains of the original nose are pared, and all surfaces to which it is intended that the new flap shall unite are freshened with scissors or knife, and then the arm is brought up to the head, the flap trimmed to the exact necessary shape, and fastened in its new position by numerous sutures, after which the hand is placed upon the top of the head, and hand and forearm suitably bandaged thereto by a somewhat complicated combination of slings and bandages: a substitute for the original apparatus may be made of plaster of Paris. As soon as the flap is supposed to be firmly ad-

FIG. 244.



Warren's Apparatus for resorting to Tagliacozzi's Method.

herent, say in ten or twelve days, its pedicle is divided and trimmed as may be necessary. The columna is subsequently made from the upper lip. The original operation contemplated that the flap should be made from the arm. Modern operators have modified it by taking it from the forearm, but the necessary confinement of head and arm is so irksome that the operation is at present scarcely ever done, although in certain cases it offers good prospect of success, provided the subject be patient and acquiescent.

The other operation, now generally practised, is that commonly known as the Indian method, and was brought to Europe from Hindoostan. The model and the pattern are made as before, but the flap is now taken from the forehead, still allowing one-third for shrinkage, the pattern being applied either perpendicularly or obliquely, depending much upon its contour (Fig. 245) and

FIG. 245.



Indian Method of Rhinoplasty (Prince).

the distance between the eyebrows and the hair. The incision is carried down to the periosteum, beginning at the right margin of the defect and terminating at the upper end of the left superciliary ridge, the pedicle of the flap being about two centimeters wide. It is necessary not to interfere with the angular artery, since upon it depends the nourishment of the flap, but the flap thus outlined is dissected off and is made to include the frontal aponeurosis. Sometimes the periosteum is raised, at least over the lower part of

the flap. Koenig has suggested to raise along with the periosteum the outer table of the skull or at least its superficial portion, especially along the central and lower portion, in order that a firm bony bridge of the nose may be produced. If this be done—and the writer has practised this with success and urges its performance—the integument should in no wise be raised from that portion of the periosteum and bone which it is intended to utilize. Except in the very young it will be impossible to detach this bone with the chisel or any other instrument in anything like a continuous layer: the bone-flap will, in fact, be more like a series of thin flat chips which cling to the periosteum. By virtue of the osteoblasts which abound on the outer surface of the bone and in the deeper layer of the periosteum, perfect osteogenetic power is preserved, and the result will be the same. As soon as hemorrhage has subsided the flap is rotated into its proper position, and the process of attachment with fine and rather numerous sutures begun. The alæ and nostrils are formed by an inward duplication of the lateral parts, and the septum is formed from the appropriate portion and stitched down to the outer portion of the upper lip, in which a groove should be made for it. The more perfect the apportionment of amount the more ornamental the result. The defect in the forehead will at first be larger than the size of the flap, since the edges will retract. It will be worth while to dissect the tissues loose from the frontal bone for an inch or two all round this defect, in order that by sliding and by the tension of silk sutures the size of the defect may be reduced at least by one-half. Sometimes it will be worth while to extend the incisions upon the scalp, so that by rearrangement of the flaps the defect may be still further covered. The portions which cannot thus be protected must be allowed to heal by granulation, or it may be possible to accomplish a good deal by skin-grafting after

Thiersch's method. The wound upon the forehead is best dressed with iodoform and green silk protective underneath the ordinary aseptic dressing. The new nose may need some artificial support, which can be furnished externally with a dressing of cotton or collodion, while internally the nostrils are kept patent and the flap supported by the introduction of rubber tubes. It is best to make the flap apparently too large, since the new organ, which seems disproportionately large at first, will in the course of months shrink and perhaps cause disappointment because not large enough. Noses thus built up are often very satisfactory, and leave but little evidence of the somewhat extensive disturbance by which they were first produced.

For more exact descriptions and variations in methods the reader is referred to the special works on plastic surgery. When from one cause or another it may appear impracticable to reproduce this organ by plastic surgery, much may be done by plastic art in another direction, and artificial noses are now prepared from celluloid or similar materials, which are kept firmly in place by spectacle-rims, as if the patient were wearing glasses. These can be made with such accuracy and worn with such exactness and comfort as almost to defy detection except on close inspection.

SECTION II.—DISEASES AND INJURIES OF THE LARYNX AND TRACHEA.

CONGENITAL DEFORMITIES AND DEFECTS.

Congenital absence of one or more of the laryngeal cartilages has been noted, as well as a relative diminution in size of the entire larynx. In a few cases also membranous partitions or connections between the various parts, by which their action is interfered with or made impossible, have been observed. The most common congenital anomalies about the parts, however, are fissures and fistulæ. These are to be attributed to defect in normal closure of the third or fourth branchial cleft or to defect in union of the third or fourth branchial arch during foetal existence. In the former case the opening would be unilateral and in the neighborhood of the sterno-mastoid muscle; in the latter case in the middle line. Fissure of the epiglottis has also been observed. Tracheal fistulæ are the least uncommon of all these anomalies, and may be so minute as to elude ordinary examination. The symptoms are the daily discharge of two or three drops of muco-purulent fluid from a minute orifice in one of the localities mentioned, with perhaps the expulsion of air-bubbles on forced expiration. The treatment of these congenital openings must consist in stimulation of the margin by caustics or in the performance of a plastic operation.

LARYNGITIS.

Laryngitis may be either acute or chronic, and may be catarrhal, croupous, diphtheritic, ulcerative, tubercular, or syphilitic. If it be of a suppurative character, it is anatomically submucous, and clinically is spoken of as phlegmonous, save when circumscribed, when we have an abscess of the larynx.

Acute Catarrhal Laryngitis may be primary or the result of extension from the pharynx above or from the trachea below. When idiopathic it is usually the result of exposure. It may also be mechanically induced by over-use of the parts in speaking or singing, and it may be produced by irritation of noxious vapors or by foreign bodies, as dust and smoke. Erysipelas of the larynx also is described, as well as rheumatic or gouty laryngitis. The acute forms are usually diffuse, giving rise to constant embarrassment of respiration and to

frequent violent and even suffocating attacks of coughing, with partial or complete loss of voice. Upon laryngoscopic inspection the mucous membrane will be found congested and swollen, the swelling being usually symmetrical. Accumulations of mucus at various points may simulate ulceration, and will be found especially on the vocal cords. Should the symptoms be very severe, œdema of the larynx may ensue.

The **treatment** consists in the removal of the cause when recognized; furthermore, in inhalations of steam impregnated with sedative and astringent substances, as well as in the administration of aperients and sedatives and the continuous application of cold wet compresses or else the employment of leeches over the larynx. Weak solutions of cocaine will give the same relief here that they do in similar affections in the nose, but are usually to be avoided for the reasons already given. There is danger in the application of strong astringents, such as nitrate of silver, etc., that they may produce sudden and serious œdema. The medicinal treatment of croup and of diphtheria is not considered here.

Chronic Laryngitis.—This, too, may be idiopathic or secondary. The former may be the result of repeated attacks of acute inflammation or of extension of similar trouble from above. The latter is almost always an extension of similar trouble elsewhere, and may occur in arthritis (gout), tuberculosis, syphilis, lupus, and cancer. The chronic variety is attended with thickening of mucous membrane, more or less constant irritation, and usually with hypersecretion. Erosions are unusual. A peculiar variety of chronic laryngitis called *laryngitis sicca* occurs principally in females; it involves especially the mucous glands, the viscid products of which adhere to the mucous membrane, where they dry into crusts which are sometimes fetid. These are detached by violent coughing-spells, and leave behind them excoriations which may bleed. The result of this is an atrophic and dry condition of the mucous membrane. These affections are to be treated after about the same manner as the similar condition in the naso-pharynx, namely, careful dislodgment by the alkaline antiseptic spray of mucus and crusts, and then the application of stimulating and antiseptic solutions.

ŒDEMA OF THE LARYNX.

The most violent and serious sequel of inflammation of the larynx is the condition known as œdema, which is sometimes incorrectly spoken of as œdema of the glottis. This is an infiltration of fluid into the submucous connective tissue of the larynx or that of the epiglottis or the mucous membrane immediately adjacent. This is less often a mere passive accumulation of serum than an active inflammatory fluid exudate, the fluid being sometimes sero-sanguinolent or sero-purulent. In certain cases this occurs with great rapidity, especially when serous, and may destroy life by suffocation within a very short time, an amount of infiltration which elsewhere would be trifling serving at this point to obstruct the passage of air through the narrowest portion of the air-channel. So serious is it as to call usually for the promptest surgical interference. In time past this condition was confused with that of croup. The deaths of General Washington and the empress Josephine were due to œdema, and not, as has been ordinarily stated, to croup. Of course the œdema is owing to impediment to free circulation, whether from purely inflammatory process, mechanical obstruction by tumor, or perhaps vaso-motor paralysis. It has often followed wounds, sometimes even of the neck when the larynx has not been implicated. It has been noted also in aneurysm, erysipelas, typhoid, glanders, whooping

cough, pneumonia, septicemia, etc. A death from this cause occurred on the baseball field a few years ago, due to fracture of the larynx.

The **symptoms** are sometimes so sudden that even with aid close at hand the patient dies before it can reach him. The principal symptoms are local discomfort, increasing perhaps to agony, stridor in breathing, especially in inspiration, cough, impulsive and violent, loss of voice, dysphagia and dyspnea in fatal cases, rapidly increasing to apnea and death by suffocation. Along with these of course go intense agitation, flushing of the face, then lividity, and then cyanosis, protrusion of the eyeballs, gasping respiration, and flickering pulse. The picture above presented is that of a fatal case. In a mild degree it may be imitated during the recurring attacks of œdema which accompany acute or chronic laryngitis.

The **prognosis** must depend on the predisposition and exciting cause. The principal danger is that of suffocation; if this is avoided, much, if not everything, may be accomplished by treatment.

Treatment.—When the case is not too acute, the best treatment consists in multiple punctures into the tumid mass of swollen mucous membrane, which may be made with a sharp curved bistoury, the blade of which is protected nearly to the point with adhesive plaster. If possible, this should be done with the aid of the laryngoscopic mirror. These punctures should not be made in the interior of the larynx, but upon the swelling exposed to view by means of the mirror, since, although we desire free hemorrhage, we wish to avoid entrance of blood into the air-passages. When hemorrhage is insufficient it may be encouraged by gargling with warm water or by inhalations of steam. The punctures may have to be repeated at intervals of a few hours or days. Should the case be too violent to permit the time necessary for this kind of relief, intubation or tracheotomy will be indicated. The very condition which makes suffocation threaten will make intubation at least difficult, while appropriate tubes are not usually at hand. Tracheotomy can always be done with the simplest instruments, and a patient should not be allowed to die of suffocation from this cause if a reasonably sharp penknife be at hand. Indeed, as a precautionary measure, if the patient threaten to require tracheotomy at any moment, it will be far better and safer to perform it deliberately than wait to be called to do it hastily with the chance of arriving too late. The serous infiltration usually rapidly subsides after the performance of this operation.

ABSCESS OF THE LARYNX.

This may be intra-, peri-, or retro-laryngeal. It is almost invariably a secondary affection, most frequently resulting from disease of the cartilages. Still, phlegmonous and traumatic laryngitis, tuberculosis, syphilis, glanders, smallpox, pyemia, and the exanthemata have been mentioned as determining causes. The inferior surface of the epiglottis, the internal aspect of the arytenoid cartilage, and the false vocal cord are the most frequent seats of circumscribed abscess not resulting from injury. The local symptoms are pain, dysphonia, dyspnea, dysphagia, and cough. The patient may even be threatened with suffocation.

The **diagnosis** must be made by means of the laryngoscope, though it may be impossible on account of swelling above; but ordinarily the lesion can be recognized as a swelling the base of which is red and the apex yellowish. The principal danger is from suffocation either by the condition spoken of or by œdema. Spontaneous evacuation usually occurs if surgical relief be not previously afforded. The treatment, of course, is incision with a properly curved

and guarded knife-point, guided by the laryngoscope. Should this not be feasible or should suffocation threaten, a preliminary tracheotomy should always be made. Extra-laryngeal abscess is recognizable by the common signs of this complaint, and should be treated in accordance with the ordinary rules.

PERICHONDritis AND CHONDritis.

The latter is always preceded by the former, which itself may be traumatic or secondary to previous disease. Idiopathic perichondritis is nearly if not quite unknown. The most common causes of disease of the cartilages are syphilis, tuberculosis, cancer, typhoid fever, and the exanthemata; more rarely chronic laryngitis. Pathologically distinct, clinically the two conditions are indistinguishable. The cricoid and arytenoid cartilages are those commonly involved. When there is suppuration beneath the perichondrium, necrosis of the cartilage proper occurs, and then an abscess forms which often discharges spontaneously, following which there is usually cicatricial contraction, while stenosis is the final result. Sometimes the arytenoid cartilages are thus discharged entire. The route of pus from such a source to the surface is sometimes very indirect, while fistula often results and extensive emphysema may take place.

The **symptoms** are those of more or less severe laryngitis, with pain on motion or pressure and sometimes during deglutition or phonation. Later appear hoarseness, cough, and dyspnea with paroxysms of stridor: with an attack of unusual severity there may be spontaneous evacuation followed by marked relief. By suitable external and internal examination a pretty accurate diagnosis of the location of the disease may be made, especially if an abscess has already formed and broken.

Treatment.—In the earlier stages antiphlogistic measures are indicated, with the ordinary local treatment and such constitutional medication as the condition of the patient may call for. Should swallowing become impossible, nourishment by stomach-tube or the rectum will be necessary, while when local symptoms are severe, tracheotomy or laryngotomy, with cleaning out of the abscess-cavities, is the only rational course.

ULCERS OF THE LARYNX.

These may be catarrhal, tubercular, syphilitic, or malignant. Only the catarrhal will be referred to here, the other forms being described under their respective headings. Of this we may have all degrees, from the most simple erosion to an ulcer of large extent. They are, as a rule, the result of chronic processes, but possibly of injury, especially by lodgment of foreign bodies. The mucous membrane around the periphery is usually slightly altered and sometimes infiltrated. They may be found at almost any point, but most commonly are in the neighborhood of the vocal cords or upon them; at times they are even excavated. They may vary in size from that of a pin-point up. Sometimes in laryngoscopic examination we find cicatrices showing where old ulcers have been healed.

The **symptoms** of ulceration are scarcely distinctive, and are included under those of inflammation. When the vocal cords are involved their function is correspondingly impaired, and there is partial or complete loss of voice, usually with irritating cough and severe laryngeal irritation. When the larynx is in this condition there is always danger of œdema.

Treatment.—This consists in the ordinary methods of combating inflammation and in the local application of some stimulating substance, which is

usually practised by means of a laryngeal probe upon whose tip a little nitrate of silver is fused. Perfect rest should be insisted upon, and constitutional treatment, such as the exhibition of tonics, etc., is commonly required.

STRICTURE OF THE LARYNX AND TRACHEA.

This is usually spoken of as stenosis, and may arise from causes within or without these parts. One or both may be implicated, and sometimes there is more than one stricture. When produced from without it is called *compression stenosis*, and may be the result of abscesses, of tumors of the thyroid or thymus or lymph-glands or elsewhere about the neck, of cicatrices, or of aneurysm. Sometimes the stricture is produced simply by the deflection of the respiratory tube, sometimes by pressure and occlusion. Stricture from within, or *occlusion stenosis*, may be due to congenital causes, to foreign bodies, to tumors, to cicatricial contraction following ulceration, and to paralytic or spasmodic affection of the intrinsic muscles; also to œdema, to submucous hemorrhage, to the presence of false membrane, to inflammatory adhesions, and to the result of suicidal attempts. The constriction may occur at any point, the amount varying within the extremest possible limits. Even complete obliteration is known. Its most common situation is naturally at a point where the channel is narrowest, namely, at the glottis; and here, of course, it assumes an importance begotten of anatomical location.

It will be seen, then, that constriction may be temporary or permanent, slight or most serious, and implies various degrees of organic and tissue changes. In proportion to the amount of stenosis there will be dyspnea, especially on inspiration and exertion, by which the voluntary muscles of inspiration are called upon to an unwonted degree. Loud breathing merges into stridor, and this later into an agonizing suffocative and stridulous choking respiration. In extreme cases the face is anxious and cyanotic, the pulse becomes small and frequent, and the muscular effort to breathe is most painful to witness. The symptoms are about the same no matter what may be the cause. There is always danger that in a severe case of cicatricial stenosis there may be added, at the last, an œdema of the parts which will hasten the termination.

When time and opportunity afford, a careful study of the case should be made in order to locate the stricture and determine its character, suitable measures then being decided upon. On the other hand, when the case is extreme the trachea should be opened as low as convenient, profiting by the fact that most of these lesions are located above the lowest accessible portion of the windpipe. It may be that a large tumor or abscess so occupies the inferior and middle portions of the neck that even tracheotomy will be impossible. When there is time for careful study and deliberation, the relief must depend upon the cause. At one time it may be dilatation of a cicatricial contraction, at another the removal of a polyp or other tumor either by intra- or extralaryngeal methods, at another the performance of a tracheotomy, or possibly a still more radical operation, such as removal of the larynx. At all events, tracheotomy is often the temporary and almost always the final expedient.

SYPHILIS OF THE LARYNX.

Syphilis of the larynx may be acute or chronic. There is an acute form which corresponds to the congestion and inflammation of the pharynx met with in the early portion of the secondary stage, which may give rise to temporary hoarseness and even to other signs of laryngeal irritation. When seen with a

laryngoscope the interior of the larynx will present the same livid and tumefied appearance that we recognize in the pharynx. The treatment for this form should be vigorous and constitutional, with such local measures as may be necessary to subdue irritation.

A chronic form of syphilitic laryngitis is common, and is marked by infiltration and inflexibility of mucous membrane, which, with time, go on to the formation of mucous patches or extensive granulomatous tissue-formation, or to extensive ulceration with destruction even of underlying cartilage, and in any event to more or less reduction of caliber, or sometimes to the formation of serious stenosis or even to complete occlusion.

Aside from mucous patches, extensive ulceration and even gummatous infiltration, or possibly formation of distinct gummata, may take place. About these ulcerations there is usually a symmetry of location which is one of the points of differential diagnosis between them and tubercular ulcerations. Ulceration of the epiglottis especially is a common manifestation of the tertiary stage. Such ravages as these seldom go on within the larynx without such external or other manifestations of syphilis as to leave scarcely a doubt concerning the nature of the lesion.

While local treatment is not to be excluded, the constitutional is the more important of the two, save when immediate consequences threaten.

TUBERCULOSIS OF THE LARYNX.

Primary tuberculosis of the larynx is rare. Although these cases are seen mostly by specialists, there is no reason why the general practitioner should not be able to recognize their characteristics. In the first place, there are the ordinary evidences of chronic laryngitis with thickening of the mucous membrane, which goes on to the formation of multiple ulcerations, ordinarily at first minute, coalescing later, accompanied by more or less hacking cough or alteration of the voice. There is no part of the larynx which is exempt from attack, but the most marked manifestations occur about the arytenoid cartilages, the vocal cords, and the epiglottis. The natural outlines of the larynx as seen in the mirror become blurred, and there is commonly an intumescence of the glotto-epiglottic folds and bands; later there occurs not only ulceration as such, but also the development of granulations, which, as a rule, are elevated above the surface, and which, when on the posterior wall and in the middle line, are by many authorities regarded as pathognomonic of the condition. This condition is usually secondary to pulmonary tuberculosis, but may be, as above mentioned, purely primary.

When the disease is of the primary type it requires usually to be differentiated from syphilis on the one hand and malignant disease on the other. Asymmetry of ulceration, with the peculiarity of granulation spoken of above, is always at least suggestive, while the absence on the one hand of evidences of syphilis elsewhere, and the existence on the other of a family history of consumption, or of a history of progressive emaciation, or of elevation of temperature, especially in the evening, will greatly aid in diagnosis. The crucial test, when it can be established, is the presence of tubercle bacilli, either in the infected tissue or in the sputum.

Between tubercular and malignant disease of the larynx it is at times in the early stages excessively difficult to determine, and it is necessary to watch for a time before making an absolute diagnosis. A study of family history, of temperature range, of constitutional conditions, will be of great aid. Malignant disease is more likely to have a more definite origin and limit, around

which healthy or nearly healthy tissue will be met with. Tubercular disease, on the other hand, is likely to leave its marks in almost every portion of the larynx, as well as to cause more local irritation, while there will be little if any such infiltration as to cause fixation of the larynx upon the outside or involvement of the lymphatic glands in the vicinity. More will be said on this topic when speaking of Cancer of the Larynx.

In time past primary laryngeal tuberculosis was supposed to be irretrievably fatal, but, while it is still to be regarded as of extreme gravity, much can be effected by **treatment**. This consists in both constitutional and local measures, the latter being those indicated in tubercular disease, and consisting of frequent applications of lactic acid to the ulcerated passage, and insufflation of iodoform or aristol or of some other dry antiseptic material by which tissue-changes are influenced, as well as of some anodyne powder, such as one containing very small portions of cocaine and morphia, combined perhaps with bismuth subnitrate and sugar of milk. In aggravated cases absolute rest of the larynx as enforced by a tracheotomy is sometimes of great benefit. If we could be assured that the disease was purely local, it might be justifiable to extirpate the organ, but patients thus far have proved unwilling to submit to this extreme measure at a time when it promised them any abiding benefit.

TUMORS OF THE LARYNX.

Most laryngeal tumors involve the interior surface, although they may rarely develop on the exterior, whence they may perforate.

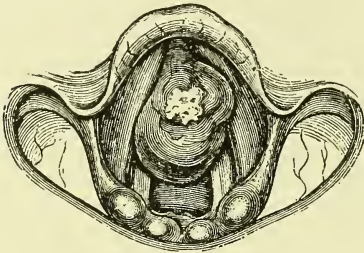
BENIGN TUMORS.—The majority of laryngeal tumors are non-malignant, and of these two-thirds are probably papillomata. Their origin is always obscure, though they are usually referred to local irritation. They are rarely multiple, and the anterior portions of the larynx are most often involved. Males are much more liable, and children frequently present this condition, even young infants. Nearly all, if not all, of the so-called benign tumors have been met with within the larynx. They vary in size from that of a small seed to masses sufficient to protrude beyond normal laryngeal limits. They occur probably with greatest frequency in the vocal cords. It must never be forgotten that the transformation of benign into malignant tumors occurs more typically here than perhaps anywhere else in the body. This would include the change of papilloma into epithelioma, of fibroma into fibro-sarcoma, and of adenoma into carcinoma, this transformation taking place usually in elderly adults at that period when age predisposes to such changes in various parts of the body.

Symptoms.—The symptoms of laryngeal tumor are uniform, no matter what its histology. They vary only according to its size and location. Hoarseness or dyspnea occurs when the action of the vocal cords is interfered with, but seldom at other times. Preceding this condition, however, is one of uncertainty of voice, with alteration of timbre and of tone limits. What is known as double voice, or diphthonia, has followed symmetrical growths dividing the glottis into two portions. Finally, complete aphonia may result. Dyspnea occurs in proportion to the amount of obstruction of the respiratory channel. When the growth is slow there appears to be a compensatory arrangement of the parts by which even a large growth will cause but little obstruction. Dysphagia is rare unless the growth occupy some portions of the pharyngeal aspect of the larynx. Cough and pain are late symptoms.

The final **diagnosis** is made with the laryngoscope: when this is impracticable, as in children, the finger-tip inserted as far as may be carefully done

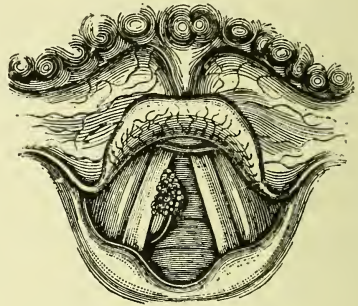
will sometimes aid. After making out the presence of the tumor in the larynx, a fine curved laryngeal probe should be introduced in order to determine its exact location and fixation. Papilloma and fibroma are usually pedunculated (Figs. 246, 247), the latter more often so than the former, and are commonly

FIG. 246.



Polyp of Larynx (Stoerck).

FIG. 247.



Papilloma of Larynx (Stoerck).

easily seen. Angiomas are usually dark in color and seated upon the vocal cords. Cysts occupy, as a rule, the ventricles or the epiglottis. Enchondromata occupy merely the posterior portion of the larynx, especially the arytenoid cartilages. With the presence of these tumors there may or may not be signs of irritation or inflammation of the surrounding parts. The principal dangers which they cause are those of suffocation, and not a few deaths have been thus induced.

Treatment.—When removal is possible it should be accomplished with the smallest necessary disturbance. They may be removed by the natural channel or after external incision. The intra-laryngeal method includes cauterization, incision, excision, crushing, snaring, and avulsion. Very small and accessible papillomata may be attacked with chromic or nitric acid or with the galvano-cautery. These are all to be used with extreme caution, for fear of resulting cedema. The instrument-makers supply cautery points by means of which, guided by the laryngoscopic mirror and a steady hand, the action of the cautery may be limited to the desired point. Incision is resorted to only in cases of cysts. Excision is performed with curved scissors or guillotine knives. When crushing is resorted to, it is with a hope of destroying vitality and causing a slough. The *écraseur* has also been employed for intra-laryngeal snaring of tumors, but is difficult to operate. Avulsion, or rudely tearing away the growth by forceps, is perhaps the most common procedure. Pedunculated masses are thus readily removed, and sessile growths can be torn away *en masse*. All these instruments can be guided by the mirror. They require special dexterity and considerable practice, and such operations are mainly relegated to specialists. Great facility has been acquired in this direction by a few, and the intra-laryngeal method in the hands of an expert offers better possibility of success than does a clumsy incision at the hands of a general practitioner.

When, however, it appears necessary to open the larynx, the operation is known as **thyrotomy** or **thyroid laryngotomy**, and consists in incision in the middle line, with splitting of the thyroid cartilage beneath the line where the two *alæ* join, and the exposure of the interior of the larynx to sight and to more radical operative attack. The thyroid being so intimately connected with the cricoid below and the hyoid above, it will be usually necessary to divide the former as well as the membrane both above and below. After whatever

growth is present has thus been removed, the cartilaginous rings may be united by suture of the perichondrium, or even through the cartilage itself. It will be wise to extend the incision downward through the first and second tracheal rings and to insert a tracheal tube, since the laryngeal wound will heal much more kindly if thus placed absolutely at rest.

MALIGNANT TUMORS.—These are composed of various forms of sarcoma and carcinoma (Fig. 248). The epiglottis is perhaps the most common seat of sarcoma, which may be met with in relatively young patients. The large proportion of true carcinomata will be found to have resulted from generations of previously benign tumors.

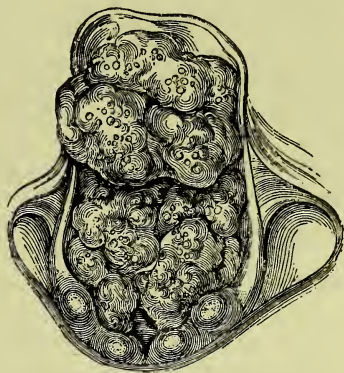
Symptoms.—So far as symptoms are concerned, they are those of benign tumors already considered, plus sensations as of foreign bodies, greater dysphagia, pain, often shooting upward toward the ears, and emaciation and lymphatic involvement. Sarcoma is much less likely to be ulcerated. That it is not always possible even for experts to settle these questions of difference of diagnosis is evidenced by the case of the late Emperor Frederick of Germany. The prognosis is always bad unless the disease can be arrested by radical operation. An encouraging percentage of cure has resulted from operations involving complete or partial removal of the larynx. One case lived nearly six years after the extirpation, and then died of an acute disease.

Treatment.—The treatment of cancer of the larynx is addressed, according to circumstances, either to alleviation or to radical cure. The former consists in local astringent and anodyne applications, with perhaps the occasional removal of projecting masses or the application of the actual cautery, by which the growth may certainly be temporarily checked in many instances. When in time the laryngeal symptoms become so severe as to harass the patient, tracheotomy will give a respite of several weeks or months. On the other hand, when the disease is apparently local and no trace of it can be found outside of proper laryngeal confines, and when the general condition and fortitude of the patient warrant so severe an operation, partial or complete extirpation of the organ may be proposed, and, with the consent of the patient, carried out. The operation of laryngotomy will be described with other operations on the parts.

TUMORS OF THE TRACHEA.

Every variety of tumor has been found within the windpipe, although tumors arise more frequently from the membranous than from the cartilaginous portion, and are more common nearer its upper portion. These tumors are often, but by no means necessarily, associated with others elsewhere. Male adults are the most often affected. The causes are absolutely obscure. A considerable number of these cases are now on record, and the condition is one which can ordinarily be recognized with the laryngoscope. The benign tumors are usually pedunculated, the malignant seldom so. The symptoms are somewhat indistinct, and do not vary much from those of laryngeal tumor, save that respiration is more permanently affected and phonation much less so, if at all. The main sign is

FIG. 248.



Carcinoma of the Larynx (Stoerck).

dyspnea, which should always lead to laryngoscopic inspection. In almost every instance a tracheotomy will be called for, and according to circumstances it may or may not be possible to remove the tumor through the same incision, which may be prolonged to the necessary extent. The operation of resection of the windpipe has been suggested, but not yet made feasible.

TRACHELOCELE.

This term is applied to a hernia of the mucous membrane of the trachea between two of its rings or through a congenital defect. The tumor thus formed on its exterior consists of a cyst of mucous membrane, the contents of which, instead of being fluid, consist of air. It may be anterior or lateral, and may vary in size from that of a pea up to that of a hen's egg. Usually unilateral, it is sometimes bilateral. It is most common in the adult male. The symptoms are dyspnea, altered voice, sometimes even aphonia. Externally there will be found a compressible gaseous tumor, which may be distended when the patient makes forced expiration with closed mouth and nose. It may come on slowly or suddenly.

The **treatment** should consist at first in pressure, although radical operation may be necessary for its cure.

WOUNDS AND INJURIES OF THE LARYNX.

These may be of external or internal origin. Those from within are caused usually by foreign bodies, those from without in various ways. The most common of the latter are **contusions**, and incised **wounds** made in suicidal or homicidal attempts. The average would-be suicide is too ignorant to make his incised wound on the side of the neck, where the great vessels would be more easily divided, but makes usually an extensive gash in front, at a point where he most commonly divides the thyro-hyoid or sometimes the crico-thyroid membrane, and the violence exerted is expended before the region of the great vessels is reached. This constitutes the ordinary form of **cut-throat**, many instances of which occur every year. Sometimes the epiglottis is partially, perhaps completely, separated, and the incision may even involve the posterior wall of the pharynx. While the wound thus inflicted opens widely by a retraction of tissue, and presents sometimes a horrible aspect, it is not nearly so dangerous as it would appear to be, the majority of these cases recovering if early and properly treated.

Treatment.—If seen early, the treatment should consist in approximation of all the divided tissues, the deeper parts being united with catgut, while for the integument catgut or silk may be used according to fancy. In certain cases local rest should be ensured by performance of a low tracheotomy, and where feeding is difficult or impossible the stomach or rectal tube may be employed so long as necessary. Aside from such injuries, punctured wounds and gunshot wounds of the larynx or trachea may occur, and call for much or little treatment according to circumstances.

Wounds of internal origin are produced mainly by foreign bodies, such as fish-hooks, needles, fish-bones, pieces of glass, etc. These may tear or puncture according to their size and location, and may excite mild or intense symptoms of laryngeal irritation with inflammation and œdema or abscess. Similar substances frequently excite spasm of the glottis, which may necessitate tracheotomy or may even kill before such aid can be rendered. In all such cases the condition should be investigated with the laryngoscope if possible. If urgent symptoms arise, tracheotomy must be performed; if seen at once, the foreign

body can often be located and removed with suitable forceps. If not seen for some hours or days, it may be so hidden by tumefaction or by exudate and membrane as to be invisible. In such a case considerable local treatment which shall be astringent, antiseptic, and anodyne may be necessary before it can be discovered. Sometimes after such injuries hemorrhage occurs by which alarming or fatal results may be brought about. In such cases, when the patient survives, there is always a possibility of secondary hemorrhage. Should bleeding be alarming, it can be best checked by a tracheotomy, with plugging of the windpipe by a tampon above the tracheal tube. To wait for its arrest by syncope is to take very much more risk than is involved in making an early incision.

FRACTURES of the larynx are known, although quite infrequent. The fracture is usually limited to the thyroid and cricoid cartilages. Such injuries are produced usually by blows from without. In elderly individuals in whom senile calcification has occurred such lesions may be produced with much less violence than in the young. The most common cases are blows with the fist or some blunt weapon, or received from balls in athletic games, attempts at choking—accidental or premeditated—and falls upon hard objects with crushing violence.

The **symptoms** must vary somewhat with the cause of the injury and its extent. A blow on the larynx which does not fracture it will often produce unconsciousness, as has been seen upon the cricket field. In 1889 a death occurred upon the baseball field, where the player was struck in the throat by a swiftly-thrown ball which fractured the larynx. He fell unconscious, and died in a few moments of oedema, timely tracheotomy not having been performed. Pain, dyspnea, cough, ejection of frothy blood and mucus, dysphonia or aphonia, and dysphagia, are the common symptoms in cases not quickly fatal. They may be followed in a short time by emphysema spreading more or less widely, and by oedema of the larynx, always serious, sometimes fatal, as above. The prognosis is most serious when the cricoid has been broken, only two cases of recovery from this injury being on record.

Treatment.—The most timely and life-saving measure that can be practised is a tracheotomy, by which at least security from suffocation will be afforded. This still leaves an injury unattended to. It has been found inadvisable to try to suture broken cartilages in these cases, even though the fracture be compound. Perfect rest, such coaptation as external support may afford, and intralaryngeal medication to some extent, will bring about the best results.

DISLOCATION of the laryngeal cartilages is known, but is very rare. The most common form is luxation of an arytenoid cartilage from the cricoid upon which it rests. This may be associated with fracture. A pathological form of dislocation is known resulting from cicatricial contraction from within or without.

The **treatment** must depend on the urgency and permanency of the symptoms. Intubation or tracheotomy will probably be called for if anything be required, while in the pathological form measures for dilatation of the stricture will be indicated.

FOREIGN BODIES IN THE AIR-PASSAGES.

The entrance of a foreign body into the air-passages is one of the commonest of accidents. Ordinarily the substance is at once expelled in a violent and reflex fit of coughing. Natural expulsion may be aided by inverting the

patient, often a child, and slapping somewhat freely upon the back. These foreign bodies are most commonly introduced in a sudden inspiration, voluntary or involuntary, while the substance is in or close to the mouth. The greatest variety of substances are thus introduced, among the more common being artificial teeth, material rejected from the stomach during the act of vomiting, including curdled milk and particles from the alimentary canal or the respiratory passages above, fragments of teeth dislodged during attempts at extraction, particles of cork or sponge, broken instruments, necrosed bone, toys, etc. On the other hand, foreign bodies enter from the outside by direct puncture, as gunshot missiles, or through previous wounds, like that described when speaking of cut-throat. Fluids of all kinds, blood, pus, etc., also have easy access to the larynx and trachea in many instances. When inorganic these materials are not likely to undergo change, but when animal or vegetable they may absorb moisture and increase in size or macerate. When retained for long periods they may become covered with mucus or even calcareous matter. They are most likely either to be entangled at a point between the epiglottis and the level of the glottis, or to pass down and become impacted in a bronchus. It frequently happens that a very small particle will cause a prodigious amount of irritation.

The usual **symptoms** are spasmodic cough, spasm of the larynx, and a feeling of suffocation. At times the symptoms are violent, and the patient may become unconscious from deficient oxidation of the blood. Foreign bodies are also the cause of some cases of prolonged and chronic laryngeal symptoms, ulceration, or abscess, in which the actual cause is either unsuspected or cannot be detected. Inspection is always necessary, and the laryngeal probe will be of great assistance. Endeavors to locate and appreciate accurately the body are always necessary, save where urgency does not warrant any delay. In not a few instances, however, suffocation occurs within the moment during which there is no one at hand with sufficient knowledge to render any assistance. Thus the writer has known of two young men who were quickly suffocated by pieces of meat within the entrance to the larynx, and more than one death which has been ascribed to anesthetics has been caused by plugging of the parts with masses of undigested food rejected from the stomach during the reflex act of vomiting. This affords a most cogent reason for insisting upon an empty stomach before beginning anesthesia, as well as turning the patient upon one side or upon the face whenever vomiting occurs during this condition of loss of voluntary control.

The **prognosis** should be always guarded, as a foreign body, which to-day causes no distress and scarcely any symptoms, months or years later may kill by a slow process of ulceration, necrosis, or something equally disastrous.

Treatment.—Except in the severest emergencies the first endeavor should be to dislodge the substance by the simplest possible manœuvres, which consist, perhaps, in inverting the body and slapping the patient on the back or chest. Many substances, like those of a mineral nature, may be thus easily dislodged and expelled. If it be a body of some size, the presumption is that it has lodged within reach of the finger, in which case the mouth should be widely opened, if necessary held so, and the index finger pushed deeply into the pharynx and swept beneath the epiglottis and down toward the glottis. If there be any substance there which the finger alone cannot dislodge, it may be aided with anything at hand which will serve the purpose. It is often well in these cases to seize the larynx from the outside with the other hand, and raise it well up toward the lower jaw, by which it is brought within better reach of the inside finger. Effort of this kind failing, artificial light and the larynx-

goscopic mirror must be brought into play, and, according to the substance at fault and the ingenuity and dexterity of the surgeon, the foreign body when seen may be grasped and removed with more or less readiness. Various kinds of forceps and other means for removing foreign bodies have been devised, and may be used as required. Finally, in cases where there is every reason to think that some foreign body is present, although it cannot be seen, the better way will be to wait, making repeated examinations, accustoming the patient to laryngoscopic methods, and cultivating the throat to tolerate the mirror. It may be possible, after a process of schooling of this kind, to see and withdraw the intruding substance. While the medical attendant should be ever ready to operate by intubation or by tracheotomy, these procedures should be held in reserve so long as there is no urgent necessity for them.

One point which the student should always bear in mind is that symptoms of laryngeal irritation sometimes exist long after the expulsion of the substance which caused them, and that patients will sometimes insist that they have not yet been relieved when it is certain that the foreign body has been expelled. Moreover, the irritation of foreign bodies is often successfully imitated in hysterical individuals.

BURNS AND SCALDS OF THE LARYNX AND TRACHEA.

These are practically never dissociated from similar injuries to the parts above, and perhaps to the œsophagus. Burns are produced by the inhalation of hot steam and superheated air. Scalds are commonly produced by hot and caustic fluids. Caustic fluids taken internally are not always swallowed, but often "go the wrong way." The consequence of these injuries is a very acute laryngitis, which supervenes at once, with excessive intumescence and œdema. In proportion to the extent and severity of the lesion will be the amount and depth of the tissue-destruction. Following the first violence of the lesion a membranous exudate is formed which separates by sloughing, and, if the patient survive, may undergo extensive cicatricial contraction. These cases are often complicated with bronchitis of a most serious and even a fatal character.

The **symptoms** produced by burns are immediate and violent; those produced by caustics may come on much more slowly.

So far as **treatment** is concerned, immediate death by suffocation can easily be averted by tracheotomy, though it may not avail to save the patient from secondary lesions. Scalds produced by caustic acids or alkalis are usually seen too late to admit of any antidote or to avert their destructive effects. The symptoms must be treated as they arise, and while the introduction of a trachea-tube will make respiration easier, the probability is that the attendant will have to treat a complicated case of lesion of the mouth and larynx, if not of the œsophagus, which will finally baffle his most persistent and well-directed efforts. Iced and mucilaginous drinks, antiseptic mouth-washes and gargles, and anodynes under the skin or by the rectum, with rectal nourishment, sum up the principal indications in the way of treatment.

TRACHEOTOMY.

Under the general term tracheotomy are included all those operations by which the respiratory channel is opened from without at any point between the thyroid cartilage and the sternum. To be more exact, we speak of *laryngotomy* when the incision is through the crico-thyroid membrane or thyroid cartilage;

of *laryngo-tracheotomy* when the cricoid and upper rings of the trachea are divided; and of *tracheotomy* proper, or, as it is sometimes improperly called, bronchotomy, when the trachea itself is opened. One or another of these operations is done, partly according to the choice of the operator and partly according to the necessities of the case. They are undertaken for, first, croup and diphtheria; second, for œdema or acute inflammatory affections; third, in syphilis and tuberculosis of the larynx in order to give it rest; fourth, for malignant disease in order to relieve obstructions to respiration; fifth, in certain rare spasmodic affections or strictures; and sixth, for the removal of foreign bodies. Many of the indications for tracheotomy have already been discussed. We do not deem it wise here to go into the question of indications in cases of croup and diphtheria, beyond this remark, that a large proportion of fatal cases are the apparent result of operations postponed too long, and that it is very unfair to the operative procedure to speak of it as having terminated fatally. It should rather be said of it that it failed to save life because too long delayed. The interests of surgery and of humanity alike dictate that operation should be done at the earliest moment after the indication has arisen. Euthanasia may be a desirable achievement after a late operation, but the rescue of a human life usually depends upon early operative interference.

Operation being decided upon, the operator is next to elect at what point he will open the windpipe. This will depend in some measure upon the time which he feels can be devoted to it, or, in other words, upon the urgency of the case. When patients are in the last gasp of dyspnea, everything else must give way to the necessity for opening the trachea at once, and even if the isthmus of the thyroid be divided or some large vein be cut, one may be sure that hemorrhage can be checked within a few seconds, and that even if blood goes into the trachea, air will go in with it.

In these circumstances the trachea will be opened wherever it can be first reached. On the other hand, when the operator is afforded plenty of time he may select his point of attack, according to the age of the patient, the relative thickness and length of the neck, and the purpose for which he is operating. The two points most commonly chosen are the cricoid cartilage and the first ring of the trachea, by which we gain access above the thyroidal isthmus, or the tracheal rings immediately below it. This isthmus of the thyroid is rather a bugbear to young operators than an actual detriment, since when met with it is but the work of a moment to slip a double ligature underneath it, tie in two places, and divide it between them, or even to catch and divide it between two pressure forceps. In young children with very short, plump necks one works with greater ease if he keeps near the larynx. On the other hand, when the trachea lies near the surface and the neck is long, and when also the light is good, the opening can be made lower down.

Tracheotomy is simple upon the cadaver, and perhaps the easiest important operation which can be there made. In a living patient, under certain circumstances, it may be equally easy, but when in the presence of a desperate emergency, with poor light and untrained assistants and a windpipe moving up and down because of the violent efforts at respiration, it may be one of the most trying ordeals which even a skilled operator has to face. Two anatomical conditions especially serve to embarrass the operator or even endanger the patient's life. The first is the plexus of veins which sometimes, but not always, is spread over the anterior surface of the trachea. In the ideal normal condition these are arranged in such a way as not to involve the middle line, but, as is often the case, they may cross it irregularly and often, and sometimes a vein of good size will present at just that portion of the tube which we have exposed

for incision. When this condition is met with, these veins may be pushed aside or may be deliberately ligated or caught with forceps, or, if exigency require, they must be divided without these precautions. They are, under these circumstances, usually engorged in connection with the very congested condition of all parts of the head and neck. As soon as a few inspirations have been taken and oxygen has had access to the blood, a restoration of equilibrium takes place and this congestion quickly subsides. Consequently, the vein which bleeds viciously for the instant may almost entirely collapse a few moments or seconds later. It will comfort young operators if they remember this fact.

The other principal anatomical danger is an adventitious or abnormal artery which arises occasionally from the arch of the aorta, or sometimes from one of the large arteries at the base of the neck, and takes its course upward along the trachea, in rare instances to its full length. It is known as the *thyroidea ima*, and may lie directly in the track of the incision. When met with it is to be dealt with as any other artery would be. It must also be borne in mind that the innominate artery sometimes courses as high as the seventh tracheal ring. Lower in the neck the trachea is deeper and smaller, and is consequently less accessible. In young children the thymus gland may also be an obstacle; consequently with them it is always desirable to work on the upper portion of the respiratory tube.

Whether in child or in adult, the head and neck should be stretched over a pillow or sand-bag, and an anesthetic should always be given, unless the patient be already unconscious or cocaine be used. The middle line is always the line of safety, and in this line the incision is made, ordinarily from the cricoid for five to seven centimeters downward. After cutting through the skin and platysma the endeavor should be made to separate or cut between the pairs of pre-tracheal muscles. The trachea is steadied with the left hand of the operator, and the incision and dissection are continued, stopping only for arrest of the hemorrhage, until the cartilages are felt. Fortunately, these are unmistakable, and so long as the operator can feel them or can find them he need have no fear of going wrong. After they have been exposed and the bleeding has been checked, a tenaculum is used to hook up the trachea, in order to bring it well to the front before incision, and to steady it. When this is once secured it should not be let go until opened. The opening is made with a pointed knife and two or three rings are divided, or the cricoid cartilage and one ring, according to circumstances. At once there is a rush of air accompanied with violent and irregular respiratory motions. During inspiration blood, if present, will be sucked into the trachea, and during expiration blood and mucus, and perhaps false membrane, will be expelled, probably into the face of the operator, a danger to be carefully guarded against, especially in diphtheria. If there be only a hissing of air, without free play, it may be known either that the opening is not large enough or that it is plugged with some shred of tissue or with false membrane or some foreign body. In the former case it must be carefully enlarged; in the latter case it should be dilated, while with forceps or probes the membrane or foreign body is removed.

It will sometimes happen that just at the most critical moment the patient, usually a child, will entirely cease to breathe. This may occur just before or just after making the opening. In this emergency the tracheal wound, if made, must be quickly searched, to learn if it be plugged; if, on the other hand, it appear to be open, the most promising procedure will be to suspend the patient by the heels and to slap vigorously on the back, or while in this position to make artificial respiration by compressing the thorax by the arms and then raising them in order to expand it.

It is advisable to insert into the trachea, on each side of the incision, a silk suture, which is ordinarily passed through the skin as well. This should be tied and the ends left hanging long. In this way a permanent and most serviceable retractor is provided, by means of which the surgeon and the nurse have absolute control of the trachea. Indeed, so simple and so effective is this manœuvre that one need never hesitate to practise tracheotomy even though he have no trachea-tube at hand, since by means of an elastic tied around the neck or extemporized hooks fastened into the suture and then connected with an elastic tape back of the neck, every purpose of the operator can be complied with. This is the so-called operation without tubes, which every practitioner should understand and be able to make in an emergency.

Trachea-tubes (Figs. 249–251) are made of hard rubber, as well as of silver and aluminum. The rubber tubes are heavy and thick, and those of aluminum are always preferable. They are made double, in order that the inner tube may be taken out and cleansed or freed from dry mucus as often as necessary. When cleansing them it is better to use an alkaline solution, by which the mucus is more readily removed.

FIG. 249.

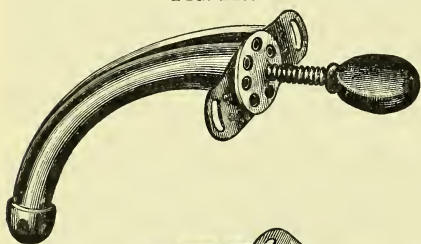
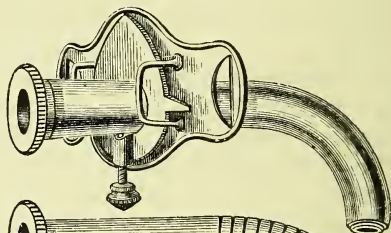


FIG. 251.



Park's Divided Trachea-Tube.

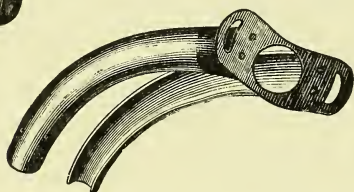
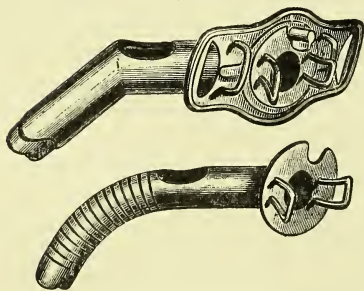
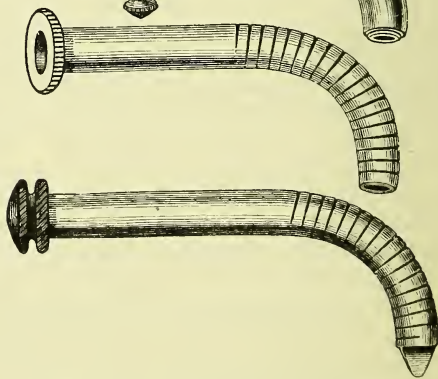


FIG. 250.



Keen's Trachea-Tube.



Johnson's Modified Durham's Trachea-Tube.

The outer tube has a little shield which is held in place by a tape passed around the neck. The largest tube which will comfortably enter the trachea should be used. In cases of obstruction from false membrane it is advisable sometimes to remove both tubes, and with a small probang firmly fastened to a handle or with a little cotton tightly wrapped around a wire quickly and dexterously to pass this down through the opening, and as quickly withdraw it, by which means membrane is dislodged and expelled by coughing. Even this procedure, however, is itself dangerous, and should not be practised oftener than may seem required by the trachea filling up with that which cannot be expelled.

After-Treatment.—The after-treatment of cases where tracheotomy has been performed requires to be almost as judiciously carried out as the operation itself. Inasmuch as air enters directly into the lungs, it should be properly warmed and moistened: the room should be kept at a temperature of 80° F. if possible, and the air kept moist with steam. Most of the conditions which necessitate tracheotomy are those which produce profound depression, and tonics and stimulants are essential. Of these strychnia and alcohol are the most desirable. The nutrition and the excretions should be carefully looked after, along with such internal medication as the surgeon may select. No rule can be given as to how long the tube should remain; this must depend upon the subsidence of the indication for which it was performed. If for a foreign body, usually one or two days; if for croup or diphtheria, five to ten days or longer; if for relief of ulceration or stenosis, perhaps for a month or months and even years; and if for temporary relief in case of cancer, until death terminates the case. Sometimes a mass of granulations develops around the tracheal wound after a few days, and causes considerable trouble either in reintroduction of the tube or in producing obstruction to respiration after its removal. Rarely they lead to cicatricial contraction later, and to what is known as **granulation stenosis** of the trachea. When present, if possible, these should be removed with caustics, with scissors, or with galvano-cautery. Other dangers connected with the operation are secondary hemorrhage, sloughing around the wound, emphysema, and ulceration and abscess. When the latter results, pus may burrow downward into the mediastinum and cause death. Cellulitis is probably the least common untoward sequel of the operation. It must be treated upon general principles.

INTUBATION OF THE LARYNX.

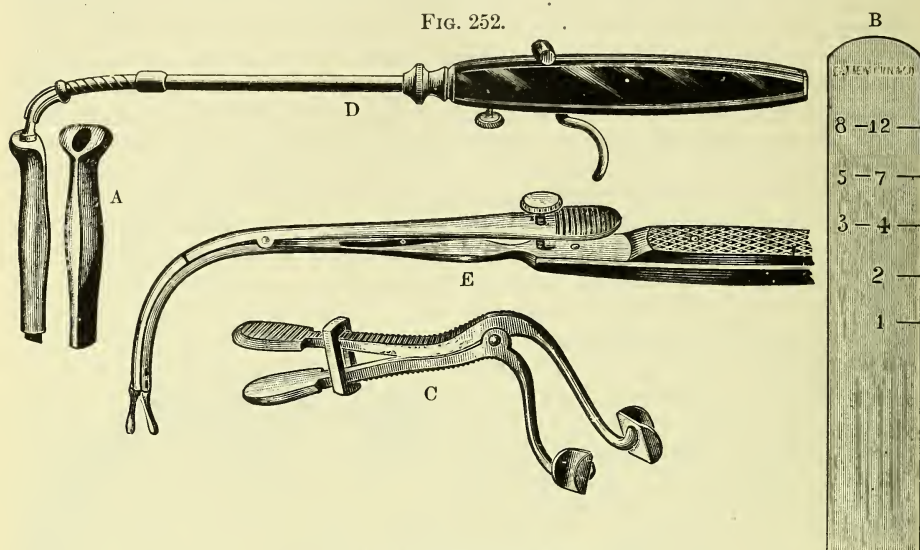
This is a distinctively American improvement upon the old operation of tracheotomy which we owe to the ingenuity and patience of O'Dwyer: not that previous efforts in this direction had not been made, but that he first made it practicable. Enough time has elapsed since its introduction to make it very plain that it constitutes a large addition to our means of affording instrumental relief, and to give it a dignity and importance which perhaps no other operation of equal simplicity possesses. The indications for the operation are, in the main, the same as those for tracheotomy. It is performed mainly in cases of diphtheria and croup, and occasionally for relief from symptoms produced by burns and scalds, by foreign bodies, and by pressure of tumors, especially those located outside the larynx; also for certain cases of ulceration and stenosis, the tube in this instance acting as a permanent dilator.

In the ordinary cases of obstruction it is obvious that the sooner it is performed the better, since by delay the patient is more exhausted and his blood more loaded with deleterious products. The originator of the operation considers that the most pressing indication for intubation is recession at those parts of the chest which yield to external air-pressure, with continued restlessness due to insufficient oxygenation, as well as feebleness of respiration. The two great advantages which intubation possesses over tracheotomy are the speed with which it can be performed and the bloodlessness and lack of shock following it. The principal disadvantage is that the necessary instruments must be at hand, while tracheotomy can be performed with almost any instruments.

As ordinarily sold, the set of intubation instruments comprises five tubes (Fig. 252, A), of sizes suitable for children from the earliest weeks of infancy up to the age of twelve. A metal gauge or scale (B) has marked upon it the lengths of the tubes and the ages for which each is suitable. Selecting the proper tube, a fine

silk thread is passed through a small hole near the anterior angle of its upper opening. This is for the purpose of retracting it if it should be lodged in a wrong

FIG. 252.



O'Dwyer's Intubation Instruments.

position. Each tube is supplied with a separate obturator, which is screwed into the handle by which it is introduced. The patient is held upright upon the lap of an assistant, the head upon the assistant's left shoulder. The arms should be secured, either by wrapping a towel or sheet around the patient's body or by being grasped below the elbows and held firmly against the body until the tube is inserted and the thread removed. Unless the hands are thus secured the patient may seize it and jerk the tube out of place. The mouth-gag (C) which accompanies the set is then inserted at the left angle of the mouth well back between the teeth, opened and clamped in such position that the mouth is open to its natural limit. Another assistant stands behind the patient with his hands firmly grasping the head, steadies it, and at the same time with his left hand keeps the gag in place. The patient should be so held that body, neck, and head are kept naturally in a straight line. The operator then, keeping the thread looped around his right little finger, holds the introducer (D) in the right hand while, inserting the index finger of the left, he seeks with the tip of it for the epiglottis, which he raises with it, thereby uncovering the glottis. By the time this is done the lower extremity of the tube has been passed down by a manœuvre much resembling that by which the laryngoscopic mirror is put in place; the index finger is now the guide by which it is passed downward into the larynx. This manœuvre is the most difficult of those by which intubation is performed. The tip of the tube must be kept in the middle line and close under and in contact with the epiglottis, which has been raised into a vertical position. At the same time the index finger must be shifted to the patient's right, in order not to take up that space in the pharynx in the middle line which the tube must now occupy as it is passed downward. As the tube is lowered by raising the other end of the handle, the introduced finger must also ascertain that it is not being passed into the œsophagus; on the contrary, that the posterior wall of the larynx can be felt behind the tube. When it is ascertained in this way positively that the tube is in the larynx, no time should be lost

in sending it home to its proper position, and at the same instant dislodging it from the obturator by pushing the slide upon the handle with the thumb of the right hand. If the upper end of the tube is not by this means sent low enough down, it can be pressed home by the finger which is still in the pharynx. It is recommended also, while the finger is still in the throat, to make sure by palpation that the tube is in place, which can be done by inserting its tip into the œsophagus and from that point feeling it in the larynx. With practice such dexterity is obtained that the entire little operation requires but a very few seconds from the time the finger is first introduced. The writer advises that, the arms of the child being still firmly held, the gag be for a few moments removed in order to make sure that there is no necessity for removing the tube at once, as well as that it is in place and affording the desired relief; then that the gag should be introduced for an instant while the finger is once more well introduced, and pressed down upon the upper end of the tube to hold it in place during the fraction of the second required to catch hold of one end of the thread and pull it out from the hole in the tube. Then the gag and the restraint are removed and the patient allowed perfect freedom. The instantaneous relief afforded by this operation is among the most cheering spectacles which the surgeon ever meets. There is usually some coughing, often with expulsion of membrane, and rarely expulsion of the tube as the result of violent cough. It is ordinarily best to reinsert the tube should it be thus expelled, using perhaps the next larger size.

The dangers of intubation are few. One danger is suffocation from too large a finger or one held too long in the larynx; consequently several rapid attempts are better than one prolonged effort. Another danger is that of pushing down membrane ahead of the tube in quantity sufficient to produce obstruction; but this happens very rarely. Should it occur, the tube must be quickly removed by the string, and then reintroduced as soon as the membrane has been expelled. Small pieces of membrane are usually coughed up and driven through the tube. Tubes when expelled from the larynx are rarely swallowed, but are ejected through the mouth. The only danger of losing the tube into the stomach is from not placing it properly in the larynx, or else from leaving the thread to be subsequently swallowed and draw the tube after it. Even if swallowed the tube will usually pass without trouble. These tubes are to be retained on an average for six days. Sometimes they may be removed sooner, or if coughed up may not need to be reintroduced. It must be remembered that they rest upon the false vocal cords, and not upon the true, and consequently the loss of voice which is apparent after their removal is not likely to be more than very temporary. Of course while the tube is in place the child can only whisper.

One positive disadvantage which these tubes entail is difficulty of deglutition, especially during the time they are worn. This is to be overcome in two or three different ways: First, by feeding the child only so small an amount of fluid that even if a part of it enter the trachea through the tube it can cause no serious irritation. Secondly, by putting the child in such position that the force of gravity will prevent this accident. This is done either by turning the child well over on its side, or, better still, by putting it in a position where the head is lower than the body while drinking or feeding. This can be easily done in spite of theoretical objections. Thirdly, by giving it food which is of semifluid consistency, and for this purpose ice-cream is often found to be soothing, palatable, and nutritious. During the time that the tube is worn the air in the room should be kept warm and moist, while such medical and local applications are continued as to the surgeon may seem fit.

Finally, after a few days comes the question of removal of the tube. This is sometimes solved by its expulsion by the patient; at other times it has to be removed by a maneuver quite similar to that by which it was introduced, the patient being held in the same way, and the left index finger being again the guide by which the point of the extractor (E) is carefully guided into the opening in the metal. The point being engaged in the caliber of the tube, the blades are sprung apart by the thumb of the right hand acting on the shank of the instrument, and the tube is, as it were, hooked out and withdrawn. This procedure is usually more difficult than the introduction of the tube, but practice, especially upon the cadaver, will quickly make perfect. These tubes are of metal plated with gold, with an expansion at their middle, and are purposely made heavy in order to prevent their spontaneous expulsion. After use in one case they must be carefully cleaned, sterilized over the flame or by boiling, and thus may be used over and over again. They may also be replated from time to time.

Intubation is also a measure which may be resorted to for the treatment of syphilitic or cicatricial stenoses of the larynx, and this simple method can be made to take the place of the more painful and less serviceable dilatations of the larynx recommended by various, especially foreign, surgeons. In a case of this kind it answers every purpose to let the patient wear an intubation-tube for a few hours, or a day or two, at a time, quieting reflex excitability, if necessary, by local applications of cocaine or by morphine or other opiates internally. The advantage of the continuous dilatation lasting for several hours over a momentary dilatation by an instrument like Schroetter's will be apparent at once.

The systematic practice of intubation has been a distinct advance in the surgery of the windpipe and larynx, and a larger proportion of lives can be saved by this measure than by anything else that we know of. When the question of operative relief is raised, it should therefore be decided, if practicable, in favor of intubation early performed.

One practical hint in the after-treatment of cases either of tracheotomy or intubation seems of great importance, and that is not to lose sight of the fact that many of these little patients, especially those suffering from diphtheria, are in a state of profound systemic poisoning, with the heart muscle very much weakened, and that part of the secret of after-success lies in recumbency, in proper nourishment, and in appropriate tonic and stimulant treatment addressed to the heart, for which purpose alcohol and strychnia seem especially indicated.

LARYNGECTOMY.

Resection or extirpation of the larynx is one of the modern operations conceived of on theoretical grounds and proved feasible by experiment upon animals. It is performed especially in cases of malignant tumor located within the larynx, with little or preferably no involvement of adjoining tissue. The operation has also been performed for stenosis, for lupus, for necrosis, and once or twice for tuberculosis. A few operators have not hesitated to extend the field of operation beyond the larynx proper, and in one case Langenbeck extirpated the larynx along with the hyoid bone, the base of the tongue, the submaxillary glands, and a part of the pharynx and œsophagus; during the operation he was compelled to tie both the external carotids. The operation is always one of great gravity, the amount of which nevertheless depends in an appreciable degree upon the condition of the patient. Nevertheless, its results have been so conspicuously successful in cases otherwise absolutely hopeless

that one need never hesitate to advise it when the general condition outside of the larynx is favorable.

When time is not too pressing, it is a great advantage to make a preliminary tracheotomy one or two weeks before the major operation. If the operator have his choice, the trachea should be opened high up, in order that a part or the whole of the same opening may be utilized later. This, however, is not absolutely essential, although it simplifies matters and accustoms the patient to breathing through the neck. The incision for laryngectomy should be a long one, in the middle line, from the neighborhood of the chin down well toward the sternum. This is to be deepened until the larynx proper is exposed, as well as the membranes above and below it. By careful dissection or separation, the soft parts, muscles, etc. which arise from the larynx or are adherent to it are separated from it, unless involved in the disease, in which case they are to be removed with it. Bleeding vessels are caught with forceps, and subsequently ligated if required. The isthmus of the thyroid, if not divided in the preliminary operation, must now be severed between two ligatures. The larynx and the upper ring or two of the trachea are thus freed anteriorly and laterally. The upper ring of the trachea is now carefully separated from the œsophagus without tearing it, and the latter is then carefully parted from the posterior surface of the cricoid cartilage, at the upper limit of which it terminates. Here it will be divided when the larynx is finally removed. The complete exsection of the larynx may now be begun from above through the thyro-hyoid membrane or from below by separation from the trachea,—it makes very little difference which; but, inasmuch as the patient is now breathing through the trachea-tube, it is necessary that blood should be prevented from trickling down the trachea along the side of the tube. This is done by tamponing with sponge or by using some form of tampon canula. The superior and lateral continuations of the larynx are now rapidly divided and the larynx quickly lifted out of its position. This being done and all hemorrhage checked, careful search is made to see that no remnants of the disease are left. The epiglottis is usually removed with the rest of the larynx, although when completely free from disease it has sometimes been left. Still, little is gained by leaving it, and it is probably better always to remove it. The wound of the previous tracheotomy having probably been reached in the more complete operation, the trachea-tube, which should be now large enough completely to fill the trachea, may be inserted through the previous opening or may be shifted so as to enter the upper divided end of the trachea.

The resulting wound is large and will gape widely, but experience shows that it is best to make little if any effort toward reuniting it, as it will heal quickly by granulation, with rapidity commensurate with the rearrangement of the parts under the new conditions established. The posterior wall of the œsophagus being continuous with that of the pharynx, the anterior portion will be divided at a point at the level of the cricoid. While the rest of the wound is tamponed with antiseptic gauze, and while the trachea-tube must be firmly packed with the same, it will be well so to arrange the packing that easy access may be had to the œsophageal opening, in order that should the patient vomit the whole dressing need not be disturbed, and in order also that after a day or two it may be utilized for stomach-feeding by the introduction of a stomach-tube. The air of the room should be kept moist and warm. The patient should be fed by the rectum for a little while, and nothing which may irritate the stomach or provoke vomiting should be permitted to enter it. After the first day or two the patient is fed with milk, raw egg, and peptonized meat preparations by the stomach-tube, which may be inserted three or

four times in the twenty-four hours, unless it has been left permanently in place, as is often done. After two or three weeks the wound will probably have so far filled up with granulations that the feeding-tube will have to be passed by the mouth.

As cicatrization follows the granulating processes, preparation should be made for the introduction of some artificial substitute for the larynx. This is known as the artificial larynx, and is commonly made of light metal, usually of silver. It consists of a trachea-tube of large size, through an opening in the upper surface of which passes a second or pharyngeal tube, the upper extremity of which occupies nearly the level of the glottis. If an opening in each has been made to correspond, air may enter through the mouth and pass down the windpipe, provided the external opening be closed with a cork or plug. Until the patient has acquired the ability to swallow under the new conditions it will be necessary for him to pass upward from without through the upper tube an obturator which shall so close it that food may not pass down into it; but after a while patients learn to swallow without this, and to breathe and whisper with ease. A further refinement has been made by the introduction, into the interior of the tube, of a vibrating metal reed which shall take the place of the vocal cords, and by which tone may be produced. This is so modified by the parts above, as in normal voice-production, that a number of patients supplied with this attachment have been able not merely to speak, but also to articulate so plainly as to be easily heard and understood at reasonable distance.

Unilateral laryngectomy is a modification of the foregoing which includes the removal of a lateral half of the larynx, naturally for disease limited to one side. It is performed upon the same general principles as the complete extirpation, but while less formidable in theory and in description, it is perhaps a more difficult operation, inasmuch as the mechanical details have to be carried out in a restricted space. The partial operation has been successful in about one-half of the total number of instances, and the complete operation in something like 25 or 30 per cent.

SECTION III.—INJURIES AND DISEASES OF THE CHEST, PLEURA, AND LUNGS.

PLEURITIC EFFUSIONS.—Serous effusions into one or both pleural cavities may be the result of acute or chronic inflammation of the pleura or lungs, or both, also of the presence of tumors or foreign bodies. The tumors need not involve the pleura, but may cause passive effusions by obstructing the return circulation. The large majority, however, of cases of hydrothorax with which we have to deal are the result of so-called pleurisy with effusion. These cases become of special surgical interest, naturally, when the collection of the fluid assumes such magnitude or such permanency as to call for mechanical measures for its removal.

The **signs** of the presence of fluid in a pleural cavity are virtually the same whether this fluid be serum, blood, or pus. In brief, they are these: The patient is apt to lie on the affected side, by which the sound lung is afforded better play. On inspection there will be found limitation of motion of this side, and the intercostal spaces may bulge or at least be level with the surfaces of the ribs. The apex of the heart, too, will be dislocated to one side or to the other in proportion to the quantity of fluid present. Its displacement to the left is never so great as that to the right. The liver may be displaced downward. On palpation there is no friction; fremitus and vocal fremitus are diminished or lost over the fluid. When the chest wall is œdematous the con-

tained fluid is purulent. By measurement the affected side will be found larger than the well side. Upon percussion there will be dullness over the lower and posterior surface of the chest, giving place to flatness, and, as fluid is increased in amount, accompanied by a sensation of increased resistance under the percussing finger. This dullness will have a certain level, which in all probability will alter with the position of the patient, while there will be pulmonary resonance just above this line. When the amount of fluid is very great, flatness may extend upward to the clavicle. Over the sound lung there is exaggerated vesicular resonance upon auscultation; the respiratory murmur is weak or absent over those portions occupied by fluid, while, as the lung is compressed, the breathing takes on a bronchial character. In mild cases friction sounds are sometimes heard.

When these signs are found, one may be quite sure of the presence of fluid. In order positively to prove the diagnosis, if such conviction be required, the needle of a hypodermatic syringe or of an aspirator may be introduced; through this thin serum will always flow. It may be possible, however, for a small needle to become clogged by a fragment of blood-clot or of fibrin or of caseous pus, so that while the discovery of fluid with a fine needle is always positive evidence, failure with the same needle to get fluid is not necessarily the reverse, and only with the large-sized needle can this question be settled.

EMPHYEMA.

This term is applied to a collection of pus in any cavity, but by common consent, unless some other cavity is specified, it is understood to refer to that of the pleura. Pus may be found here as the result of the same causes that bring about serous effusion, plus the contamination by organisms from the lungs or more remotely through the systemic circulation. In cases of penetrating injury of the pleura, when air has entered this cavity it is not unlikely that collections of blood or serum will become thus directly contaminated, and empyema be the result almost from the outset. As a rule, however, it is the result, perhaps the termination, of a chronic process. In recent cases the pleura does not have time to become very much thickened; but in long-standing cases, especially those in which spontaneous perforation has occurred, the pleura becomes infiltrated and altered, so as to lose all resemblance to its original structure, and to be found sometimes a centimeter thick. Under these conditions it is more like leather than like a living tissue. A collection of pus having occurred within the pleural cavity from any cause, several possibilities exist for it: its fluid portion may be gradually absorbed and its solid material remain to cement the pleural surfaces together and to caseate, and finally to disappear; or it may excite further production of fluid of the same character, which will produce such urgent symptoms as to necessitate relief; or it may evacuate itself either by rupture into a bronchus or bronchiole and escape by the mouth or by perforation elsewhere in any one of various directions. Thus it has been known to burrow down around the external intercostal muscles which terminate under the intercostal cartilages and to appear at various points about the thorax, or to perforate or burrow around the fibers of the diaphragm and cause perhaps a subdiaphragmatic abscess, or to take some other unusual course. It has, for instance, been known to perforate behind the mammary gland, and, pushing itself forward, to assume enormous size as a retro-mammary abscess; or to separate the diaphragm, and then the peritoneum, and to make such a dissection of it from the abdominal wall as to appear in the pelvis and in the abdominal wall as an enormous extra-peritoneal abscess.

But these are unusual cases, and it ordinarily gives rise to the same character of disturbance as a collection of serous fluid, with the addition of the constitutional signs of the presence of pus, such as chills, irregular high temperature, emaciation, hectic, etc.

I. The *idiopathic* forms of empyema may be thus classified:

- a. Staphylococcus and streptococcus form of infection of pleuritic exudate.
- b. Diplococcus form, from Fränkel's diplococcus pneumoniae, probably originally the result of a pleuro-pneumonia, the pneumonic lesion having cleared up.
- c. Tubercular form, the result of tubercular pleurisy, which may be contaminated with pyogenic cocci.
- d. Secondary and embolic form, due to a suppurative focus elsewhere (e. g. retro-pharyngeal abscess, perforating peritonitis, pyemia, etc.).
- e. Putrid form, from contamination by saprophytic bacteria.

II. The *traumatic* form must be regarded as comprising cases of—

Simple and mixed infection from burns, wounds, foreign bodies, etc.

The surgical treatment of empyema—and it scarcely permits any other—is by paracentesis, *i. e.* aspiration, or free incision and drainage. In simple cases the former may be first tried, as described above. Serious or long-standing cases should not have time thus wasted upon them, but should be subjected at once to some form of thoracotomy (p. 626).

HEMOTHORAX.

By this term is meant a collection of blood in the pleural cavity. It is almost always of traumatic origin, although the possibility of spontaneous hemorrhage cannot be excluded. We meet with it most often in cases of fractured ribs, where a sharp fragment of bone has scraped the surface of the lung during respiration until the lung is removed from harm's way by the presence of serum or blood pressing it away. Furthermore, it is seen in cases of gunshot or stab wound where an intercostal artery or some vessel in the lung has been divided, and where blood, even to fatal amount, has collected. The general physical signs already given in some detail will point to the presence of fluid, and the history of the case or of the injury, with aspiration, if necessary, will enable the surgeon to decide which condition he has to deal with.

OPERATIVE TREATMENT OF FLUID COLLECTIONS IN THE PLEURAL CAVITIES.

PARACENTESIS.—The indications for removal of fluid from the pleural cavities, without reference to the stage of the disease, in moderate effusions are dyspnea and distress, and the recognition of the presence of large amounts of fluid, whether other symptoms and signs are violent or not; furthermore, the failure of nature or art to cause resorption within reasonable time, on the average three weeks; spontaneous perforation into the lung; the presence of fever, perhaps with chills, and bulging of intercostal spaces, with œdema of the overlying skin, which are supposed to indicate the presence of pus; or the certainty from the history and physical signs that blood has been poured out and has not been resorbed. There are other reasons than the mere necessity to obtain immediate relief why evacuation should be secured. By the presence of fluid the lung is naturally compressed and its integrity impaired, with a prospect of permanent injury to its function if it be not permitted to resume its former shape and size within a reasonable time. We may also be sure that

the longer it has been compressed the less elastic it is and the more difficult will be its expansion.

PARACENTESIS THORACIS.—The term paracentesis is applied to evacuation of fluid from any cavity, the particular cavity being specified in the name of the operation. To Bowditch of Boston is due the credit of having first applied suction for the evacuation of fluid effusions, a method which has now become so general as scarcely to call for comment. For this purpose there are needed a hollow needle or fine trocar, some flexible tubing, and some mechanical device for suction. In the absence of all other means, siphonage may be practised through a yard or more of rubber tubing first filled with aseptic solution and its lower end kept constantly under water; or a Davidson syringe may be used, or one of the more elegant forms of aspirator, or the Allen surgical pump, although if the emergency be very dire an ordinary trocar, or even the puncture of a tenotome blade, may be resorted to. The two main indications are to withdraw the fluid and to prevent the admission of air. If air can be kept out, the lung must necessarily tend to expand in order to take the place of the fluid which is removed. Inasmuch as this should be anything but a rapid process, the needle should be only large enough to permit fluid to run easily through it and carry perhaps with it fine flocculi of fibrin, otherwise pulmonary hemorrhage, or at least violent intrathoracic distress, might ensue. Before using it the needle should be cleaned and polished and then sterilized by passing it through the alcohol flame. Unless patients are too weak to sit up, they are placed in a sitting posture. It is well to give a little stimulant before and perhaps during the operation. The needle is inserted in an intercostal space either just below the lower angle of the scapula at the back, or at the side just in front of the latissimus dorsi muscle. Before introducing the needle the skin should be scoured and made aseptic; and it should be inserted quickly. It is perhaps well to guard the needle with the finger, lest by too forcible a plunge it be inserted too far. There is always a possibility with a too fine needle that some particle of fibrin or clot or caseated pus may obstruct it so that nothing will flow out. Most of the aspirator needles are provided with wires which may be inserted into them after being cleansed, and with which they may be cleared out. Should fluid still refuse to come, especially if the anterior end of the needle appear to work freely as if in a cavity, it is better to withdraw it to see that it is clear, and then to introduce a larger one. The withdrawal of a needle should be done as quickly as its introduction; after which the puncture is sealed with plaster or collodion.

Sometimes patients become so weak or faint that it is necessary to put them in the recumbent position or even to stop the aspiration for the time. The sudden expansion of the previously compressed lung certainly does often cause a most disagreeable sensation, while the withdrawal of the fluid perhaps allows the heart quickly to return to its normal position, by which its action may be temporarily disturbed. Perfect rest should be enforced for a number of hours after the operation.

Should the lung persistently refuse to re-expand after repeated tapplings, it is scarcely worth while to make many efforts. Constitutional treatment with tonics will probably do more for these cases than surgery. However, should it be necessary after prolonged effort to do something, it would have to be in the line, probably, of excision of ribs as described below. It has been recently found that empyema, following pneumonia, is occasionally cured by tapping. When, therefore, the pneumococcus is found tapping should first be done.

When the effused fluid is purulent the **prognosis** after simple aspiration

is not nearly so good. In rare instances, especially in children, and in pneumonic empyemas, one or two tappings may suffice, but a condition of empyema or pyothorax differs but little from any other large abscess, save that it has a bony and unyielding wall, and it calls for incision and drainage after the same fashion.

THORACOTOMY.

Thoracotomy, or opening the wall of the thorax for evacuation of collections of fluid, consists simply in an incision, perhaps two inches long, through the skin over an intercostal space, the opening through the pleura being an inch or half an inch in length. When performing this operation the skin should be cleansed, as well as the operator's hands; the skin may then be slid upward for an inch or more above the point at which the opening is to be made, in order that when it returns to its place it shall exercise somewhat of a valve-like action. This will be of little use so long as the drainage-tube is in use, but may be of service later. To avoid a mistake it is well before finally dividing the pleura to insert a needle or fine trocar to see if pus be underneath. If found, no hesitation need be felt in perforating the pleura, being careful only not to push the knife too far in; or in allowing the pus to escape, which it will probably do by jets because of the patient's breathing or coughing. The best point at which to puncture is at the side just in front of the latissimus dorsi muscle, certainly not lower than the eighth interspace, and perhaps even as high as the sixth. Here the pleura is near the surface, and we gain the advantage of gravity in draining the chest, while drainage-tubes at this point cause little discomfort. Of course air enters the chest through the external opening, the air-pressure on each side of the lung is equalized, and there is no fear of distress from too rapid expansion of the lung. The pus from these cases is frequently fetid, but the fetor will usually disappear in a short time. Some surgeons advise washing out the pleural cavity, by which means pus-clots are removed and fetor of discharge is subdued, but when there is neither fetor nor débris discharged it is perhaps as well to omit irrigation. When this latter is practised we may use strong or saturated boric solutions or solutions of mercuric chloride, 1 : 5000, followed by boiled water or dilute Labarraque's solution. Through the incision one or, preferably, two good-sized stout drainage-tubes are inserted and fastened by silk sutures to the skin. They should be just long enough to reach from without fairly into the pleural cavity, and are introduced partly for purposes of washing and drainage, and partly to keep the opening from healing too quickly.

In some instances the ribs are so close together that any tube will be collapsed by their pressure upon it. When this is the case a section of rib, probably of the seventh, about an inch in length, should be removed. After the complete evacuation of an empyemic cavity a large quantity of antiseptic and absorbent dressing should be placed outside the wound, and over all this some impervious covering such as rubber dam. Outside this an elastic bandage around the chest will be of advantage, provided it be not too uncomfortable. This dressing should be renewed the following day, and after that every second day. As soon as the discharge becomes serous, and has diminished to a very small amount, one drainage-tube may be removed, and the second when the amount is no greater than would be caused by the presence of the tube. When the chest has thus been opened, expansion of the collapsed lung is finally attained in many cases.

EXCISION OF RIB.—In certain cases it is evident at the outset, and in other cases it becomes patent later, that mere incision with insertion of drain-

age-tubes will not afford large enough and permanent enough vent. In such cases it is a common practice to remove a section of one or two ribs through a single external incision, the bony pieces being from one to two inches long. This makes a somewhat more formidable operation than the foregoing, and is advisable mostly in cases of longer standing. Whenever it is necessary to incise the chest for this purpose, we must expect to find the pleura altered from a thin parchment-like membrane into one which seems more like leather, and which may be correspondingly tough.

THORACOPLASTY (ESTLANDER'S OPERATION).

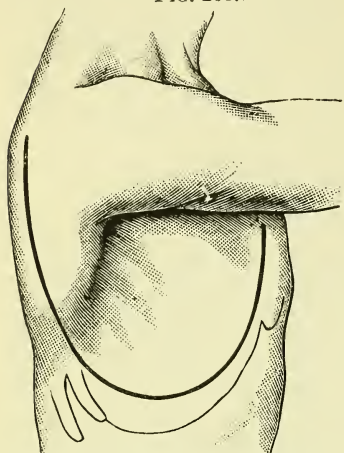
Finally, the surgeon is called at times to cases where the empyemic condition has existed for a long time, or where an encysted collection has formed, or where spontaneous perforation has occurred, so that he has to deal with a thoracic fistula, discharging at times a small, at times a large, amount of pus. In these instances the pleura has become so rigid and inflexible, and the lung so fixed in its abnormal position, that even if the cavity be widely opened by the ordinary method it is impossible for it to heal, since the lung cannot expand from within nor can the chest-wall collapse from without. The ribs now act like parallel hoops, and serve to preserve a cavity which we urgently desire to obliterate. This may be somewhat diminutive in size, or may be almost commensurate with the entire space normally occupied by one lung. It is in these cases that the thoracoplastic method devised by Estlander has rendered the most signal service. It is based simply on the theory that inasmuch as the inner wall of the cavity cannot expand to meet the ribs, the ribs must be so divided as to permit them to fall toward and meet the lung tissue. It offers a prospect of final cure for cases which are otherwise beyond such possibility. The smaller the cavity the simpler the operation, though one may not be deterred from resorting to it in extreme cases. Before deciding to operate, however, it would be well carefully to examine the patient and the urine, in order to recognize such signs of amyloid changes as would make it unwise to give anesthetics or perform any severe operation.

Inasmuch as it is usually necessary to attack several ribs, we must plan our incisions in such cases according to the size of the cavity and the amount of collapse desired. In the more simple cases it is enough to make a long incision from the axilla downward, and simply to divide or perhaps remove pieces from the third to the eighth or ninth rib. At other times an incision is made both in front and behind, and posteriorly at the inner border of the scapula, by which three or four ribs may be divided in front and from three to seven behind. Such an operation as this is very severe, and leaves the patient with a large passage clear through the chest.

When performing this operation, if the patient's strength hold out, it is well to do more than simply divide the ribs and the enormously thickened pleura. This pleura is practically the wall of an immense abscess, and from it shreds of membrane and disorganized tissue may hang like stalactites from the roof of a cavern. These cases are also usually tubercular, and such membrane is fraught with danger. It is advisable, therefore, to scrape and cut away from both pleural surfaces as much of it as can be safely removed without exciting too serious hemorrhage. No fear need be felt from the intercostal arteries, since it is a simple matter to check the hemorrhage with catch forceps and to pinch the bones sufficiently to compress the arteries. The altered pleura, as a rule, is not vascular, and it is surprising how so formidable an operation can be made with so little loss of blood. No attempts should be made to suture or

close the wound, but it is left as widely open as possible, and perhaps packed in order to keep it so. As granulations spring up on the freshened pleural

FIG. 253.



Incision for Schede's Operation of Thoracoplasty (Esmarch and Kowalzig).

surfaces we have a gradual process of healing by second intention or adhesion of granulating surfaces, by which the lung will be gradually drawn outward and the chest drawn inward. Considerable restoration of function also occurs.

Schede's Operation.—In old cases, in which the pleura may be an inch thick, Schede has devised a still more radical operation. An incision (Fig. 253) is made from the level of the axilla in front to the second rib behind, the convexity of the incision reaching to the lowest limit of the pleura. The large flap is dissected loose down to the ribs, the scapula being lifted from the trunk. The ribs, from the second downward, from the costal cartilages to the tubercles, and the entire muscular chest-wall and the pleura, are then removed by large scissors or bone-forceps and the flap is replaced on the lung

after thorough curetting. Any bleeding arteries are tied. Healing generally takes place by first intention.

GANGRENE OF THE LUNGS.

This may be either idiopathic or traumatic. It is more common in the lower than in the upper lobes. There are a diffuse and a circumscribed form. The former is usually of the embolic variety. Gangrene here, as elsewhere, is the result of bacterial invasion and putrefaction. The lungs may be invaded from within by foreign bodies taken in by inhalation or by "swallowing the wrong way." It occurs in marasmic patients, in the insane, in those that cannot swallow well nor cough, and in those with bulbar paralysis. It may also result from necrotic processes in the pharynx or larynx; also from perforation of septic foci from other tissue, as through the pleura or diaphragm, or from carious vertebræ or infected bronchial glands. It develops secondarily also from such conditions as fetid bronchitis or croupous pneumonia or bronchial dilatation; also by embolic processes from gangrenous bed-sores, puerperal septicemia, etc. It furthermore occurs as the result of injuries, such as lacerations, compound fractures, gunshot and stab wounds, etc.; or as the result of severe contusions with cerebral concussion by which respiration is interfered with and venous stasis encouraged; or by such injuries as cause endocarditis.

The clinical signs of gangrene of the lungs much resemble those of fetid bronchitis. The sputum as well as the breath has a most repulsive odor, and if the former be collected in a glass it forms usually three layers, the lower one consisting almost wholly of pus and débris. When of traumatic origin we have intense local and prolonged pain, severe initial chills, pyrexia, and, later, fetid expectoration. If the gangrene is localized in the lungs, ulceration may take place; when the pleura is involved it is fatal. By physical examination we can sometimes easily map out the extent of the gangrenous condition. Sometimes we get even the signs of a cavity. If such be near the surface, we may

be sure of adhesion between lung and chest-wall, and may see here a plain indication for surgical interference.

This may be rapidly and successfully performed by free incision down to the pleura, with resection of one or more ribs if necessary, and then the opening of the gangrenous pulmonary cavity, which is usually performed with the cautery knife. The danger of the operation can be scarcely as great as that of the condition if left unrelieved.

SURGERY OF THE LUNG.

Modern experimental methods have shown that in certain cases and in certain ways it is not only possible, but judicious, to attack the human lung. Centuries of clinical observation have made it clear that the entrance of air into the pleural cavity either from within or from without is by no means fatal, but may be an incident quickly recovered from. So long, then, as air has access, it matters little whether it be through a small opening or through a large one; that is to say, if necessary, we can expose the lung by a large incision. Thus far, the lungs have been attacked in cases of wounds, especially for the relief of hemorrhage, of gangrene, of abscess whether due to gangrene, dilated bronchi, or tubercular disease, for the drainage of cysts, for the removal of solid tumors, for the excision of foci of tubercular disease; and they may properly be attacked in certain cases for the removal of foreign bodies. We may distinguish between simple incision, or *pneumotomy*, and exsection of a portion of lung tissue, or *pneumectomy*.

Experiments on animals have shown that two-thirds or more of one lung can be removed through an incision in the thoracic wall with almost perfect impunity. So much as this of a human lung has as yet never been safely removed, but small portions have. Vivisection teaches us that although one pleural cavity be opened and its lung collapsed and made temporarily useless, the animal can get sufficient oxygen by respiring with the other lung, and that in case oxygenation be deficient or respiration suddenly stopped, it may be continued by artificial means almost indefinitely. Consequently, if the human patient must be subjected to some such ordeal as this, the surgeon should have at hand a trachea-tube and bellows or means for inducing artificial respiration. In the operations recorded, however, it has seldom been necessary to resort to them.

PNEUMOTOMY in the presence of disease consists practically in the measures described above for opening gangrenous cavities. This is where we expect to find the lung adherent to the chest-wall. Should we fail to find it thus fixed, the lung should be drawn up toward the surface and snugly fastened there by a row of sutures. Within a few hours adhesion will have taken place, and the cautery may be used for penetrating deeper, as above mentioned. This would presumably be the better method for dealing with a foreign body in the lungs, provided we can locate it, and if it cannot be located it will be inadvisable to operate unless the chest has been already widely opened and the lung collapsed. In one instance after a stab wound of the chest a man was allowed to die because it was held that a large vessel in his lung had been wounded and that his condition was consequently helpless. It was found later, however, that the bleeding all came from an intercostal artery, through which the man had bled to death into his own chest. In this case the result might have been very different had free incision been made and the source of the hemorrhage sought for.

PNEUMECTOMY may be done in a similar way, as when a hernia of the

lung, recent or old, is excised; or it may be forced upon a surgeon when in operating upon a malignant tumor of the chest he finds the lung adherent behind it and involved in the disease. Success has been obtained in such cases, the wound in the lung tissue being closed according to usual methods. Or it may be done with deliberation, as in the case where an Italian surgeon resected a tubercular lobe from one lung of his *fiancée*, and later committed suicide because of the fatal effect of his operation.

INTRATHORACIC TUMORS.

Intrathoracic tumors may spring either from the thoracic wall or from the thoracic viscera. Of the former, the most common are exostoses and enchondromata, which may develop in pedunculated form or as extensive sessile masses involving several bones or cartilages. Malignant tumors, the most common of which are sarcomata or mixed tumors, also develop in the same way. Tumors springing from the thoracic wall, whether developed internally or externally, constitute legitimate subjects for consideration with reference to operative relief, the decision being grounded upon their character, extent, and probable adhesion to the viscera of the thorax. Operations by which portions of several ribs involved in such tumors are excised have been performed with success, as well as operations for the removal of the sternum when that is the primary seat of the disease. They are extensive and most severe, and should never be made without a statement of their dangers to the patient and his assumption of risks. In most if not all of them the costal pleura at least will be so involved that free opening of the pleural cavity, with collapse of the lung, is inevitable. There would be no object in attacking such growths were the overlying integument so involved as to prevent its preservation for covering the defect. When, however, the tumor simply involves one or two ribs only, and is of an osseous or cartilaginous nature, it is quite possible in most cases to remove it, subperiosteally, without opening the pleura. But little danger attends such cases.

Tumors involving the contents of the thorax lie, for the most part, outside the present domain of operative surgery. Nevertheless, a few of them demand operative measures. Such, for instance, are substernal dermoid cysts, hydatid tumors of the lung, actinomycotic masses, and possibly others of non-malignant character. Most of such growths are, in the first place, difficult or impossible of diagnosis, and in the second place involve parts too vital to admit of interference.

The **diagnosis** is made largely by a process of exclusion, as well as by symptoms of pressure upon nerves and vessels and by a study of physical signs. While the future may have it in store for us, the time has hardly yet arrived when it will be considered advisable to open the thorax for purely exploratory and diagnostic purposes, although little fear may be felt about the careful use of the aspirator needle. The microscopic study of the sputum may also yield valuable evidence. If a solid tumor in any way could be recognized as involving a circumscribed part of one lung, it might be warrantable to remove the affected portion. It has very recently been suggested to open the thorax from behind by resecting ribs from a line near their angles to the inner side of the scapula, by which reasonable access is permitted to the root of the lung. Some such procedure as this may be made serviceable in selected cases by bold operators. Possibly also certain aneurysms within the thorax may be attacked in this way.



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